

# Sunshine Duration Analysis as a First Step to Estimate Solar Resource for Photovoltaic Electricity Production in Middle Latitudes

Environmental Processes

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## Abstract

This paper analyzes the spatio-temporal variability of sunshine duration in the south of the Pampeana region as a first approach to solar climatic analysis, main input for the use of this resource. Hourly sunshine duration records from 1991 to 2015 in eight Argentine cities were analyzed using statistics and geospatial techniques. In addition, we analyzed the frequency of clear sky and overcast days in order to relate it to the sunshine duration variability. Sunshine duration in the Pampeana region presented a linear gradient increasing in an east-west direction. An inverse relationship between the mean sunshine duration and coefficients of variation was found in all the cities. The highest mean values of sunshine duration were recorded located between 62°W and 65°W, where the lowest variability was also registered. The city of Mar del Plata showed the lowest mean values of sunshine duration (4.5 h) and the highest percentage of variability (78.1%), whereas Río Colorado recorded the highest mean values of sunshine duration (7.5 h) and the lowest variability (51.1%) over the observation period. During the warm season, it was recorded a difference of 3.7 h in the mean SD values between the stations Río Colorado and Mar del Plata. The spatial distribution of the solar resource in the Pampena region is

markedly affected by weather systems playing at the regional scale of South America. In the cold season, the west-east movement of the high pressure cells promotes the occurrence of Sudestadas, which explain the variability of sunshine duration over the coastal areas.

## Keywords

Sunshine duration Cloudiness Spatio-temporal variability Pampeana region  
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## Notes

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## Compliance with Ethical Standards

## Conflict of Interest

The authors declare that they have no conflict of interest.

## References

Adam MEN (2011) Effect of macrophysical parameters of clouds on broadband solar radiation (295–2800 nm) at a subtropical location. *Atmospheric and Oceanic Science Letters* 4:181–185  
[CrossRef](https://doi.org/10.1080/16742834.2011.11446926) (https://doi.org/10.1080/16742834.2011.11446926)  
[Google Scholar](http://scholar.google.com/scholar_lookup?title=Effect%20of%20macrophysical%20parameters%20of%20clouds%20on%20broadband%20solar%20radiation%20%28295%20-%202800%20nm%29%20at%20a%20subtropical%20location&author=MEN.%20Adam&journal=Atmospheric%20and%20Oceanic%20Science%20Letters&volume=4&pages=181-185&publication_year=2011) (http://scholar.google.com/scholar\_lookup?title=Effect%20of%20macrophysical%20parameters%20of%20clouds%20on%20broadband%20solar%20radiation%20%28295%20-%202800%20nm%29%20at%20a%20subtropical%20location&author=MEN.%20Adam&journal=Atmospheric%20and%20Oceanic%20Science%20Letters&volume=4&pages=181-185&publication\_year=2011)

Adaramola MS (2012) Estimating global solar radiation using common meteorological data in Akure, Nigeria. *Renew Energy* 47:38–44

[CrossRef](https://doi.org/10.1016/j.renene.2012.04.005) (https://doi.org/10.1016/j.renene.2012.04.005)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Estimating%20global%20solar%20radiation%20using%20common%20meteorological%20data%20in%20Akure%2C%20Nigeria&author=MS.%20Adaramola&journal=Renew%20Energy&volume=47&pages=38-44&publication_year=2012) (http://scholar.google.com/scholar\_lookup?title=Estimating%20global%20solar%20radiation%20using%20common%20meteorological%20data%20in%20Akure%2C%20Nigeria&author=MS.%20Adaramola&journal=Renew%20Energy&volume=47&pages=38-44&publication\_year=2012)

Almorox J, Hontoria C (2004) Global solar radiation estimation using sunshine duration in Spain. *Energy Convers Manag* 45(9–10):1529–1535

[CrossRef](https://doi.org/10.1016/j.enconman.2003.08.022) (https://doi.org/10.1016/j.enconman.2003.08.022)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Global%20solar%20radiation%20estimation%20using%20sunshine%20duration%20in%20Spain&author=J.%20Almorox&author=C.%20Hontoria&journal=Energy%20Conversion%20Manag&volume=45&issue=9&pages=1529-1535&publication_year=2004) (http://scholar.google.com/scholar\_lookup?title=Global%20solar%20radiation%20estimation%20using%20sunshine%20duration%20in%20Spain&author=J.%20Almorox&author=C.%20Hontoria&journal=Energy%20Conversion%20Manag&volume=45&issue=9&pages=1529-1535&publication\_year=2004)

Anderson S (2002) An evaluation of spatial interpolation methods on air temperature in Phoenix, AZ. *Department of Geography, Arizona State University Tempe* 85287:0104

[Google Scholar](http://scholar.google.com/scholar_lookup?title=An%20evaluation%20of%20spatial%20interpolation%20methods%20on%20air%20temperature%20in%20Phoenix%2C%20AZ&author=S.%20Anderson&journal=Department%20of%20Geography%2C%20Arizona%20State%20University%20Tempe&volume=85287&pages=0104&publication_year=2002) (http://scholar.google.com/scholar\_lookup?title=An%20evaluation%20of%20spatial%20interpolation%20methods%20on%20air%20temperature%20in%20Phoenix%2C%20AZ&author=S.%20Anderson&journal=Department%20of%20Geography%2C%20Arizona%20State%20University%20Tempe&volume=85287&pages=0104&publication\_year=2002)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=An%20evaluation%20of%20spatial%20interpolation%20methods%20on%20air%20temperature%20in%20Phoenix%2C%20AZ&author=S.%20Anderson&journal=Department%20of%20Geography%2C%20Arizona%20State%20University%20Tempe&volume=85287&pages=0104&publication_year=2002) (http://scholar.google.com/scholar\_lookup?title=An%20evaluation%20of%20spatial%20interpolation%20methods%20on%20air%20temperature%20in%20Phoenix%2C%20AZ&author=S.%20Anderson&journal=Department%20of%20Geography%2C%20Arizona%20State%20University%20Tempe&volume=85287&pages=0104&publication\_year=2002)

Aparicio MP (2010) *Energía solar fotovoltaica: cálculo de una instalación aislada*.

Marcombo, Barcelona

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Energ%C3%ADa%20solar%20fotovoltaica%3A%20c%C3%A1lculo%20de%20una%20instalaci%C3%B3n%20aislada&author=MP.%20Aparicio&publication_year=2010) (http://scholar.google.com/scholar\_lookup?title=Energ%C3%ADa%20solar%20fotovoltaica%3A%20c%C3%A1lculo%20de%20una%20instalaci%C3%B3n%20aislada&author=MP.%20Aparicio&publication\_year=2010)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Energ%C3%ADa%20solar%20fotovoltaica%3A%20c%C3%A1lculo%20de%20una%20instalaci%C3%B3n%20aislada&author=MP.%20Aparicio&publication_year=2010) (http://scholar.google.com/scholar\_lookup?title=Energ%C3%ADa%20solar%20fotovoltaica%3A%20c%C3%A1lculo%20de%20una%20instalaci%C3%B3n%20aislada&author=MP.%20Aparicio&publication\_year=2010)

Argungu GM, Dabai KA (2017) Application of linear models for estimation of global solar radiation using available meteorological parameters for Sokoto, Nigeria. *International Journal of Advances in Scientific Research and Engineering* 3(11):76–83

[Google Scholar](https://scholar.google.com/scholar?q=Argungu%20GM%2C%20Dabai%20KA%20%282017%29%20Application%20of%20linear%20models%20for%20estimation%20of%20global%20solar%20radiation%20using%20available%20meteorological%20parameters%20for%20Sokoto%2C%20Nigeria.%20International%20Journal%20of%20Advances%20in%20Scientific%20Research%20and%20Engineering%203%2811%29%3A76%E2%80%9383) (https://scholar.google.com/scholar?q=Argungu%20GM%2C%20Dabai%20KA%20%282017%29%20Application%20of%20linear%20models%20for%20estimation%20of%20global%20solar%20radiation%20using%20available%20meteorological%20parameters%20for%20Sokoto%2C%20Nigeria.%20International%20Journal%20of%20Advances%20in%20Scientific%20Research%20and%20Engineering%203%2811%29%3A76%E2%80%9383)

[Google Scholar](https://scholar.google.com/scholar?q=Argungu%20GM%2C%20Dabai%20KA%20%282017%29%20Application%20of%20linear%20models%20for%20estimation%20of%20global%20solar%20radiation%20using%20available%20meteorological%20parameters%20for%20Sokoto%2C%20Nigeria.%20International%20Journal%20of%20Advances%20in%20Scientific%20Research%20and%20Engineering%203%2811%29%3A76%E2%80%9383) (https://scholar.google.com/scholar?q=Argungu%20GM%2C%20Dabai%20KA%20%282017%29%20Application%20of%20linear%20models%20for%20estimation%20of%20global%20solar%20radiation%20using%20available%20meteorological%20parameters%20for%20Sokoto%2C%20Nigeria.%20International%20Journal%20of%20Advances%20in%20Scientific%20Research%20and%20Engineering%203%2811%29%3A76%E2%80%9383)

Assi A, Jama M (2010) Estimating global solar radiation on horizontal from sunshine hours in Abu Dhabi–UAE. In: Kallel A, Hassairi A, Bulucea CA, Mastorakis N (eds)

*Advances in energy planning, environmental education and renewable energy sources, 4th WSEAS International Conference on Renewable Energy Sources*. University of Sfax, Tunisia, pp 101–108

[Google Scholar](https://scholar.google.com/scholar?q=Assi%20A%2C%20Jama%20M%20%282010%29%20Estimating%20global%20solar%20radiation%20on%20horizontal%20from%20sunshine%20hours%20in%20Abu%20Dhabi%20UAE.%20In%3A%20Kallel%20A%2C%20Hassairi%20A%2C%20Bulucea%20CA%2C%20Mastorakis%20N%20%28eds%29%20Advances%20in%20energy%20planning%2C%20environmental%20education%20and%20renewable%20energy%20sources%2C%204th%20WSEAS%20International%20Conference%20on%20Renewable) (https://scholar.google.com/scholar?q=Assi%20A%2C%20Jama%20M%20%282010%29%20Estimating%20global%20solar%20radiation%20on%20horizontal%20from%20sunshine%20hours%20in%20Abu%20Dhabi%20UAE.%20In%3A%20Kallel%20A%2C%20Hassairi%20A%2C%20Bulucea%20CA%2C%20Mastorakis%20N%20%28eds%29%20Advances%20in%20energy%20planning%2C%20environmental%20education%20and%20renewable%20energy%20sources%2C%204th%20WSEAS%20International%20Conference%20on%20Renewable

[Google Scholar](https://scholar.google.com/scholar?q=Assi%20A%2C%20Jama%20M%20%282010%29%20Estimating%20global%20solar%20radiation%20on%20horizontal%20from%20sunshine%20hours%20in%20Abu%20Dhabi%20UAE.%20In%3A%20Kallel%20A%2C%20Hassairi%20A%2C%20Bulucea%20CA%2C%20Mastorakis%20N%20%28eds%29%20Advances%20in%20energy%20planning%2C%20environmental%20education%20and%20renewable%20energy%20sources%2C%204th%20WSEAS%20International%20Conference%20on%20Renewable) (https://scholar.google.com/scholar?q=Assi%20A%2C%20Jama%20M%20%282010%29%20Estimating%20global%20solar%20radiation%20on%20horizontal%20from%20sunshine%20hours%20in%20Abu%20Dhabi%20UAE.%20In%3A%20Kallel%20A%2C%20Hassairi%20A%2C%20Bulucea%20CA%2C%20Mastorakis%20N%20%28eds%29%20Advances%20in%20energy%20planning%2C%20environmental%20education%20and%20renewable%20energy%20sources%2C%204th%20WSEAS%20International%20Conference%20on%20Renewable

%20Energy%20Sources.%20University%20of%20Sfax%2C%20Tunisia%2C%20Opp%20101%E2%80%93108)

Azpurua MA, Ramos KD (2010) A comparison of spatial interpolation methods for estimation of average electromagnetic field magnitude. *Prog Electromagn Res* 14:135–145

[CrossRef](https://doi.org/10.2528/PIERM10083103) (https://doi.org/10.2528/PIERM10083103)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=A%20comparison%20of%20spatial%20interpolation%20methods%20for%20estimation%20of%20average%20electromagnetic%20field%20magnitude&author=MA.%20Azpurua&author=KD.%20Ramos&journal=Prog%20Electromagn%20Res&volume=14&pages=135-145&publication_year=2010) (http://scholar.google.com/scholar\_lookup?title=A%20comparison%20of%20spatial%20interpolation%20methods%20for%20estimation%20of%20average%20electromagnetic%20field%20magnitude&author=MA.%20Azpurua&author=KD.%20Ramos&journal=Prog%20Electromagn%20Res&volume=14&pages=135-145&publication\_year=2010)

Badescu V (2002) A new kind of cloudy sky model to compute instantaneous values of diffuse and global solar irradiance. *Theor Appl Climatol* 72(1–2):127–136

[CrossRef](https://doi.org/10.1007/s007040200017) (https://doi.org/10.1007/s007040200017)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=A%20new%20kind%20of%20cloudy%20sky%20model%20to%20compute%20instantaneous%20values%20of%20diffuse%20and%20global%20solar%20irradiance&author=V.%20Badescu&journal=Theor%20Appl%20Climatol&volume=72&issue=1%E2%80%932&pages=127-136&publication_year=2002) (http://scholar.google.com/scholar\_lookup?title=A%20new%20kind%20of%20cloudy%20sky%20model%20to%20compute%20instantaneous%20values%20of%20diffuse%20and%20global%20solar%20irradiance&author=V.%20Badescu&journal=Theor%20Appl%20Climatol&volume=72&issue=1%E2%80%932&pages=127-136&publication\_year=2002)

Badosa J, Haeffelin M, Chepfer H (2013) Scales of spatial and temporal variation of solar irradiance on Reunion tropical island. *Sol Energy* 88:42–56

[CrossRef](https://doi.org/10.1016/j.solener.2012.11.007) (https://doi.org/10.1016/j.solener.2012.11.007)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Scales%20of%20spatial%20and%20temporal%20variation%20of%20solar%20irradiance%20on%20Reunion%20tropical%20island&author=J.%20Badosa&author=M.%20Haeffelin&author=H.%20Chepfer&journal=Sol%20Energy&volume=88&pages=42-56&publication_year=2013) (http://scholar.google.com/scholar\_lookup?title=Scales%20of%20spatial%20and%20temporal%20variation%20of%20solar%20irradiance%20on%20Reunion%20tropical%20island&author=J.%20Badosa&author=M.%20Haeffelin&author=H.%20Chepfer&journal=Sol%20Energy&volume=88&pages=42-56&publication\_year=2013)

Benson RB, Paris MV, Sherry JE, Justus CG (1984) Estimation of daily and monthly direct, diffuse and global solar radiation from sunshine duration measurements. *Sol Energy* 32(4):523–535

[CrossRef](https://doi.org/10.1016/0038-092X(84)90267-6) (https://doi.org/10.1016/0038-092X(84)90267-6)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Estimation%20of%20daily%20and%20monthly%20direct%2C%20diffuse%20and%20global%20solar%20radiation%20from%20sunshine%20duration%20measurements&author=RB.%20Benson&author=MV.%20Paris&author=JE.%20Sherry&author=CG.%20Justus&journal=Sol%20Energy&volume=32&issue=4&pages=523-535&publication_year=1984) (http://scholar.google.com/scholar\_lookup?title=Estimation%20of%20daily%20and%20monthly%20direct%2C%20diffuse%20and%20global%20solar%20radiation%20from%20sunshine%20duration%20measurements&author=RB.%20Benson&author=MV.%20Paris&author=JE.%20Sherry&author=CG.%20Justus&journal=Sol%20Energy&volume=32&issue=4&pages=523-535&publication\_year=1984)

Bosch JL, Kleissl J (2013) Cloud motion vectors from a network of ground sensors in a solar power plant. *Sol Energy* 95:13–20

[CrossRef](https://doi.org/10.1016/j.solener.2013.05.027) (https://doi.org/10.1016/j.solener.2013.05.027)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Cloud%20motion%20vectors%20from%20a%20network%20of%20ground%20sensors%20in%20a%20solar%20power%20plant&author=JL.%20Bosch&author=J.%20Kleissl&journal=Sol%20Energy&volume=95&pages=13-20&publication_year=2013) (http://scholar.google.com/scholar\_lookup?title=Cloud%20motion%20vectors%20from%20a%20network%20of%20ground%20sensors%20in%20a%20solar%20power%20plant&author=JL.%20Bosch&author=J.%20Kleissl&journal=Sol%20Energy&volume=95&pages=13-20&publication\_year=2013)

Bosch JL, Zheng Y, Kleissl J (2013) Deriving cloud velocity from an array of solar radiation measurements. *Sol Energy* 87:196–203

[CrossRef](https://doi.org/10.1016/j.solener.2012.10.020) (https://doi.org/10.1016/j.solener.2012.10.020)

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Deriving%20cloud%20velocity%20from%20an%20array%20of%20solar%20radiation%20measurements&author=JL.%20Bosch&author=Y.%20Zheng&author=J.%20Kleissl&journal=Sol%20Energy&volume=87&pages=196-203&publication\\_year=2013](http://scholar.google.com/scholar_lookup?title=Deriving%20cloud%20velocity%20from%20an%20array%20of%20solar%20radiation%20measurements&author=JL.%20Bosch&author=Y.%20Zheng&author=J.%20Kleissl&journal=Sol%20Energy&volume=87&pages=196-203&publication_year=2013))

Bràzdil R, Flocas AA, Sahsamanoğlu SH (1994) Fluctuation of sunshine duration in central and South-Eastern Europe. *Int J Climatol* 14(9):1017–1034

**CrossRef** (<https://doi.org/10.1002/joc.3370140907>)

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Fluctuation%20of%20sunshine%20duration%20in%20central%20and%20South-Eastern%20Europe&author=R.%20Br%C3%A0zdil&author=AA.%20Flocas&author=SH.%20Sahsamanoğlu&journal=Int%20J%20Climatol&volume=14&issue=9&pages=1017-1034&publication\\_year=1994](http://scholar.google.com/scholar_lookup?title=Fluctuation%20of%20sunshine%20duration%20in%20central%20and%20South-Eastern%20Europe&author=R.%20Br%C3%A0zdil&author=AA.%20Flocas&author=SH.%20Sahsamanoğlu&journal=Int%20J%20Climatol&volume=14&issue=9&pages=1017-1034&publication_year=1994))

Capelli de Steffens AM, Piccolo MC, Campo de Ferreras AM (2005) Clima urbano de Bahía Blanca. Departamento de Geografía y Turismo de la Universidad Nacional del Sur, Bahía Blanca

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Clima%20urbano%20de%20Bah%C3%ADa%20Blanca&author=AM.%20Capelli%20de%20Steffens&author=MC.%20Piccolo&author=AM.%20Campo%20de%20Ferreras&publication\\_year=2005](http://scholar.google.com/scholar_lookup?title=Clima%20urbano%20de%20Bah%C3%ADa%20Blanca&author=AM.%20Capelli%20de%20Steffens&author=MC.%20Piccolo&author=AM.%20Campo%20de%20Ferreras&publication_year=2005))

Capitanelli RG (2008) Los ambientes naturales del territorio argentino. Un sistema basado en la diversidad. In: Roccatagliata J (ed) *Argentina: una visión actual y prospectiva desde la dimensión territorial*. Emecé Editores, Buenos Aires, pp 63–120

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Los%20ambientes%20naturales%20del%20territorio%20argentino.%20Un%20sistema%20basado%20en%20la%20diversidad&author=RG.%20Capitanelli&pages=63-120&publication\\_year=2008](http://scholar.google.com/scholar_lookup?title=Los%20ambientes%20naturales%20del%20territorio%20argentino.%20Un%20sistema%20basado%20en%20la%20diversidad&author=RG.%20Capitanelli&pages=63-120&publication_year=2008))

Celemín AH (1984) *Meteorología práctica*. Edición del Autor, Mar del Plata

**Google Scholar** (<https://scholar.google.com/scholar?q=Celem%C3%ADn%20AH%20%281984%29%20Meteorolog%C3%ADa%20pr%C3%A1ctica.%20Edici%C3%B3n%20del%20Autor%2C%20Mar%20del%20Plata>)

Chen FW, Liu CW (2012) Estimation of the spatial rainfall distribution using inverse distance weighting (IDW) in the middle of Taiwan. *Paddy Water Environ* 10(3):209–222

**CrossRef** (<https://doi.org/10.1007/s10333-012-0319-1>)

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Estimation%20of%20the%20spatial%20rainfall%20distribution%20using%20inverse%20distance%20weighting%20%28IDW%29%20in%20the%20middle%20of%20Taiwan&author=FW.%20Chen&author=CW.%20Liu&journal=Paddy%20Water%20Environ&volume=10&issue=3&pages=209-222&publication\\_year=2012](http://scholar.google.com/scholar_lookup?title=Estimation%20of%20the%20spatial%20rainfall%20distribution%20using%20inverse%20distance%20weighting%20%28IDW%29%20in%20the%20middle%20of%20Taiwan&author=FW.%20Chen&author=CW.%20Liu&journal=Paddy%20Water%20Environ&volume=10&issue=3&pages=209-222&publication_year=2012))

Chen JL, Li GS (2013) Estimation of monthly average daily solar radiation from measured meteorological data in Yangtze River basin in China. *Int J Climatol* 33(2):487–498

**CrossRef** (<https://doi.org/10.1002/joc.3442>)

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Estimation%20of%20monthly%20average%20daily%20solar%20radiation%20from%20measured%20meteorological%20data%20in%20Yangtze%20River%20basin%20in%20China&author=JL.%20Chen&author=GS.%20Li&journal=Int%20J%20Climatol&volume=33&issue=2&pages=487-498&publication\\_year=2013](http://scholar.google.com/scholar_lookup?title=Estimation%20of%20monthly%20average%20daily%20solar%20radiation%20from%20measured%20meteorological%20data%20in%20Yangtze%20River%20basin%20in%20China&author=JL.%20Chen&author=GS.%20Li&journal=Int%20J%20Climatol&volume=33&issue=2&pages=487-498&publication_year=2013))

De Miguel A, Bilbao J, Salson S, Lage A (1994) Solar radiation and sunshine hour maps in Castilla and León region (Spain). *Renew Energy* 4:933–940

[CrossRef](https://doi.org/10.1016/0960-1481(94)90227-5) (https://doi.org/10.1016/0960-1481(94)90227-5)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Solar%20radiation%20and%20sunshine%20hour%20maps%20in%20Castilla%20and%20Le%C3%B3n%20region%20%28Spain%29&author=A.%20Miguel&author=J.%20Bilbao&author=S.%20Salson&author=A.%20Lage&journal=Renew%20Energy&volume=4&pages=933-940&publication_year=1994) (http://scholar.google.com/scholar\_lookup?title=Solar%20radiation%20and%20sunshine%20hour%20maps%20in%20Castilla%20and%20Le%C3%B3n%20region%20%28Spain%29&author=A.%20Miguel&author=J.%20Bilbao&author=S.%20Salson&author=A.%20Lage&journal=Renew%20Energy&volume=4&pages=933-940&publication\_year=1994)

Escobar G, Vargas W, Bischoff S (2004) Wind tides in the Rio de la Plata estuary: meteorological conditions. *Int J Climatol* 24(9):1159–1169

[CrossRef](https://doi.org/10.1002/joc.1026) (https://doi.org/10.1002/joc.1026)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Wind%20tides%20in%20the%20Rio%20de%20la%20Plata%20estuary%3A%20meteorological%20conditions&author=G.%20Escobar&author=W.%20Vargas&author=S.%20Bischoff&journal=Int%20J%20Climatol&volume=24&issue=9&pages=1159-1169&publication_year=2004) (http://scholar.google.com/scholar\_lookup?title=Wind%20tides%20in%20the%20Rio%20de%20la%20Plata%20estuary%3A%20meteorological%20conditions&author=G.%20Escobar&author=W.%20Vargas&author=S.%20Bischoff&journal=Int%20J%20Climatol&volume=24&issue=9&pages=1159-1169&publication\_year=2004)

Fadare DA (2009) Modelling of solar energy potential in Nigeria using an artificial neural network model. *Appl Energy* 86(9):1410–1422

[CrossRef](https://doi.org/10.1016/j.apenergy.2008.12.005) (https://doi.org/10.1016/j.apenergy.2008.12.005)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Modelling%20of%20solar%20energy%20potential%20in%20Nigeria%20using%20an%20artificial%20neural%20network%20model&author=DA.%20Fadare&journal=Appl%20Energy&volume=86&issue=9&pages=1410-1422&publication_year=2009) (http://scholar.google.com/scholar\_lookup?title=Modelling%20of%20solar%20energy%20potential%20in%20Nigeria%20using%20an%20artificial%20neural%20network%20model&author=DA.%20Fadare&journal=Appl%20Energy&volume=86&issue=9&pages=1410-1422&publication\_year=2009)

Fathey AM (1992) Ultraviolet solar radiation at Helwan and its dependence on atmospheric conditions. Thesis, Faculty of Science, Helwan University, Egypt, M.Sc

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Ultraviolet%20solar%20radiation%20at%20Helwan%20and%20its%20dependence%20on%20atmospheric%20conditions&author=AM.%20Fathey&publication_year=1992) (http://scholar.google.com/scholar\_lookup?title=Ultraviolet%20solar%20radiation%20at%20Helwan%20and%20its%20dependence%20on%20atmospheric%20conditions&author=AM.%20Fathey&publication\_year=1992)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Ultraviolet%20solar%20radiation%20at%20Helwan%20and%20its%20dependence%20on%20atmospheric%20conditions&author=AM.%20Fathey&publication_year=1992) (http://scholar.google.com/scholar\_lookup?title=Ultraviolet%20solar%20radiation%20at%20Helwan%20and%20its%20dependence%20on%20atmospheric%20conditions&author=AM.%20Fathey&publication\_year=1992)

Fernández García F (1996) *Manual de Climatología Aplicada*. Editorial Síntesis, Madrid

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Manual%20de%20Climatolog%C3%ADa%20Aplicada&author=F.%20Fern%C3%A1ndez%20Garc%C3%ADa&publication_year=1996) (http://scholar.google.com/scholar\_lookup?title=Manual%20de%20Climatolog%C3%ADa%20Aplicada&author=F.%20Fern%C3%A1ndez%20Garc%C3%ADa&publication\_year=1996)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Manual%20de%20Climatolog%C3%ADa%20Aplicada&author=F.%20Fern%C3%A1ndez%20Garc%C3%ADa&publication_year=1996) (http://scholar.google.com/scholar\_lookup?title=Manual%20de%20Climatolog%C3%ADa%20Aplicada&author=F.%20Fern%C3%A1ndez%20Garc%C3%ADa&publication\_year=1996)

Fernández ME, Campo AM, Gentili O (2015) Comportamiento temporal de la radiación solar global en la ciudad de Bahía Blanca, Argentina. *Revista de Climatología* 15:51–64

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Comportamiento%20temporal%20de%20la%20radiaci%C3%B3n%20solar%20global%20en%20la%20ciudad%20de%20Bah%C3%ADa%20Blanca%20C%20Argentina&author=ME.%20Fern%C3%A1ndez&author=AM.%20Campo&author=O.%20Gentili&journal=Revista%20de%20Climatolog%C3%ADa&volume=15&pages=51-64&publication_year=2015) (http://scholar.google.com/scholar\_lookup?title=Comportamiento%20temporal%20de%20la%20radiaci%C3%B3n%20solar%20global%20en%20la%20ciudad%20de%20Bah%C3%ADa%20Blanca%20C%20Argentina&author=ME.%20Fern%C3%A1ndez&author=AM.%20Campo&author=O.%20Gentili&journal=Revista%20de%20Climatolog%C3%ADa&volume=15&pages=51-64&publication\_year=2015)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Comportamiento%20temporal%20de%20la%20radiaci%C3%B3n%20solar%20global%20en%20la%20ciudad%20de%20Bah%C3%ADa%20Blanca%20C%20Argentina&author=ME.%20Fern%C3%A1ndez&author=AM.%20Campo&author=O.%20Gentili&journal=Revista%20de%20Climatolog%C3%ADa&volume=15&pages=51-64&publication_year=2015) (http://scholar.google.com/scholar\_lookup?title=Comportamiento%20temporal%20de%20la%20radiaci%C3%B3n%20solar%20global%20en%20la%20ciudad%20de%20Bah%C3%ADa%20Blanca%20C%20Argentina&author=ME.%20Fern%C3%A1ndez&author=AM.%20Campo&author=O.%20Gentili&journal=Revista%20de%20Climatolog%C3%ADa&volume=15&pages=51-64&publication\_year=2015)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Comportamiento%20temporal%20de%20la%20radiaci%C3%B3n%20solar%20global%20en%20la%20ciudad%20de%20Bah%C3%ADa%20Blanca%20C%20Argentina&author=ME.%20Fern%C3%A1ndez&author=AM.%20Campo&author=O.%20Gentili&journal=Revista%20de%20Climatolog%C3%ADa&volume=15&pages=51-64&publication_year=2015) (http://scholar.google.com/scholar\_lookup?title=Comportamiento%20temporal%20de%20la%20radiaci%C3%B3n%20solar%20global%20en%20la%20ciudad%20de%20Bah%C3%ADa%20Blanca%20C%20Argentina&author=ME.%20Fern%C3%A1ndez&author=AM.%20Campo&author=O.%20Gentili&journal=Revista%20de%20Climatolog%C3%ADa&volume=15&pages=51-64&publication\_year=2015)

Fernández ME, Gentili JO, Campo AM (2014) Diseño e implementación de una base de datos geográficos para el análisis de registros de radiación global de Bahía Blanca y Punta Alta. In: Uboldi JA, Ángeles GR, Gentili JO, Gernaldi AM, Melo WD, Carbone ME (Comp) *Geotecnologías del sur argentino. Casos de estudio*. Departamento de Geografía y Turismo, Universidad Nacional del Sur, Bahía Blanca, pp 414–422

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Dise%C3%B1o%20e%20implementaci%C3%B3n%20de%20una%20base%20de%20datos%20geogr%C3%A1ficos%20para%20el%20an%C3%A1lisis%20de%20registros%20de%20radiaci%C3%B3n%20global%20de%20Bah%C3%ADa%20Blanca%20y%20Punta%20Alta&author=ME.%20Fern%C3%A1ndez%20Gentili%20JO%20Campo%20AM&author=Uboldi%20JA%20A%C3%A1ngeles%20GR%20Gentili%20JO%20Gernaldi%20AM%20Melo%20WD%20Carbone%20ME&publication_year=2014) (http://scholar.google.com/scholar\_lookup?title=Dise%C3%B1o%20e%20implementaci%C3%B3n%20de%20una%20base%20de%20datos%20geogr%C3%A1ficos%20para%20el%20an%C3%A1lisis%20de%20registros%20de%20radiaci%C3%B3n%20global%20de%20Bah%C3%ADa%20Blanca%20y%20Punta%20Alta&author=ME.%20Fern%C3%A1ndez%20Gentili%20JO%20Campo%20AM&author=Uboldi%20JA%20A%C3%A1ngeles%20GR%20Gentili%20JO%20Gernaldi%20AM%20Melo%20WD%20Carbone%20ME&publication\_year=2014)

odatos%20geogr%C3%A1ficos%20para%20el%20an%C3%A1lisis%20de%20registros%20de%20radiaci%C3%B3n%20global%20de%20Bah%C3%ADa%20Blanca%20y%20Punta%20Alta&author=ME.%20Fern%C3%A1ndez&author=JO.%20Gentili&author=AM.%20Campo&pages=414-422&publication\_year=2014)

Gemmer M, Becker S, Jiang T (2004) Observed monthly precipitation trends in China 1951–2002. *Theor Appl Climatol* 77(1–2):39–45

[CrossRef](https://doi.org/10.1007/s00704-003-0018-3) (https://doi.org/10.1007/s00704-003-0018-3)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Observed%20monthly%20precipitation%20trends%20in%20China%201951%E2%80%932002&author=M.%20Gemmer&author=S.%20Becker&author=T.%20Jiang&journal=Theor%20Appl%20Climatol&volume=77&issue=1%E2%80%93&pages=39-45&publication_year=2004) (http://scholar.google.com/scholar\_lookup?

title=Observed%20monthly%20precipitation%20trends%20in%20China%201951%E2%80%932002&author=M.%20Gemmer&author=S.%20Becker&author=T.%20Jiang&journal=Theor%20Appl%20Climatol&volume=77&issue=1%E2%80%93&pages=39-45&publication\_year=2004)

Gil V, Gaertner MA, Sánchez E, Gallardo C, Hagel E, Tejada C, De Castro M (2015) Analysis of interannual variability of sunshine hours and precipitation over peninsular Spain. *Renew Energy* 83:680–689

[CrossRef](https://doi.org/10.1016/j.renene.2015.05.001) (https://doi.org/10.1016/j.renene.2015.05.001)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Analysis%20of%20interannual%20variability%20of%20sunshine%20hours%20and%20precipitation%20over%20peninsular%20Spain&author=V.%20Gil&author=MA.%20Gaertner&author=E.%20S%C3%A1nchez&author=C.%20Gallardo&author=E.%20Hagel&author=C.%20Tejada&author=M.%20Castro&journal=Renew%20Energy&volume=83&pages=680-689&publication_year=2015) (http://scholar.google.com/scholar\_lookup?

title=Analysis%20of%20interannual%20variability%20of%20sunshine%20hours%20and%20precipitation%20over%20peninsular%20Spain&author=V.%20Gil&author=MA.%20Gaertner&author=E.%20S%C3%A1nchez&author=C.%20Gallardo&author=E.%20Hagel&author=C.%20Tejada&author=M.%20Castro&journal=Renew%20Energy&volume=83&pages=680-689&publication\_year=2015)

Grossi Gallegos H, Righini R (2007) Atlas de Energía Solar de la República Argentina. Universidad Nacional de Luján, Buenos Aires

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Atlas%20de%20Energ%C3%ADa%20Solar%20de%20la%20Rep%C3%ABlica%20Argentina&author=H.%20Grossi%20Gallegos&author=R.%20Righini&publication_year=2007) (http://scholar.google.com/scholar\_lookup?

title=Atlas%20de%20Energ%C3%ADa%20Solar%20de%20la%20Rep%C3%ABlica%20Argentina&author=H.%20Grossi%20Gallegos&author=R.%20Righini&publication\_year=2007)

Grossi Gallegos HG, Righini C, Raichijk R (2010) Algunos aspectos de la climatología solar del Uruguay. *Revista Brasileira de Meteorología* 25:479–486

[CrossRef](https://doi.org/10.1590/S0102-77862010000400007) (https://doi.org/10.1590/S0102-77862010000400007)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Algunos%20aspectos%20de%20la%20climatolog%C3%ADa%20solar%20del%20Uruguay&author=HG.%20Grossi%20Gallegos&author=C.%20Righini&author=R.%20Raichijk&journal=Revista%20Brasileira%20de%20Meteorolog%C3%ADa&volume=25&pages=479-486&publication_year=2010) (http://scholar.google.com/scholar\_lookup?

title=Algunos%20aspectos%20de%20la%20climatolog%C3%ADa%20solar%20del%20Uruguay&author=HG.%20Grossi%20Gallegos&author=C.%20Righini&author=R.%20Raichijk&journal=Revista%20Brasileira%20de%20Meteorolog%C3%ADa&volume=25&pages=479-486&publication\_year=2010)

Grossi Gallegos HG, Spreafichi MI (2007) Análisis de las series de datos anuales en la estación Paraná-INTA. *Avances en Energías Renovables y Medio Ambiente* 11:11.31–11.36

[Google Scholar](http://scholar.google.com/scholar_lookup?title=An%C3%A1lisis%20de%20las%20series%20de%20datos%20anuales%20en%20la%20estaci%C3%B3n%20Paraná-INTA&author=HG.%20Grossi%20Gallegos&author=MI.%20Spreafichi&journal=Avances%20en%20Energ%C3%ADas%20Renovables%20y%20Medio%20Ambiente&volume=11&pages=11.31-11.36&publication_year=2007) (http://scholar.google.com/scholar\_lookup?

title=An%C3%A1lisis%20de%20las%20series%20de%20datos%20anuales%20en%20la%20estaci%C3%B3n%20Paraná-INTA&author=HG.%20Grossi%20Gallegos&author=MI.%20Spreafichi&journal=Avances%20en%20Energ%C3%ADas%20Renovables%20y%20Medio%20Ambiente&volume=11&pages=11.31-11.36&publication\_year=2007)

Grossi Gallegos HG, Spreafichi MI (2008) Análisis de tendencias de heliofanía efectiva en Argentina. *Meteor-Forschung* 32(1–2):5–17

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=An%C3%A1lisis%20de%20tendencias%20de%20heliograf%C3%ADa%20efectiva%20en%20Argentina&author=HG.%20Grossi%20Gallegos&author=MI.%20Spreafichi&journal=Meteor-Forschung&volume=32&issue=1%E2%80%932&pages=5-17&publication\\_year=2008](http://scholar.google.com/scholar_lookup?title=An%C3%A1lisis%20de%20tendencias%20de%20heliograf%C3%ADa%20efectiva%20en%20Argentina&author=HG.%20Grossi%20Gallegos&author=MI.%20Spreafichi&journal=Meteor-Forschung&volume=32&issue=1%E2%80%932&pages=5-17&publication_year=2008))

Gueymard CA, Wilcox SM (2011) Assessment of spatial and temporal variability in the US solar resource from radiometric measurements and predictions from models using ground-based or satellite data. *Sol Energy* 85:1068–1084

**CrossRef** (<https://doi.org/10.1016/j.solener.2011.02.030>)

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Assessment%20of%20spatial%20and%20temporal%20variability%20in%20the%20US%20solar%20resource%20from%20radiometric%20measurements%20and%20predictions%20from%20models%20using%20ground-based%20or%20satellite%20data&author=CA.%20Gueymard&author=SM.%20Wilcox&journal=Sol%20Energy&volume=85&pages=1068-1084&publication\\_year=2011](http://scholar.google.com/scholar_lookup?title=Assessment%20of%20spatial%20and%20temporal%20variability%20in%20the%20US%20solar%20resource%20from%20radiometric%20measurements%20and%20predictions%20from%20models%20using%20ground-based%20or%20satellite%20data&author=CA.%20Gueymard&author=SM.%20Wilcox&journal=Sol%20Energy&volume=85&pages=1068-1084&publication_year=2011))

Gutierrez-Corea FV, Manso-Callejo MA, Moreno-Regidor MP, Velasco-Gómez J (2014) Spatial estimation of sub-hour global horizontal irradiance based on official observations and remote sensors. *Sensors* 14:6758–6787

**CrossRef** (<https://doi.org/10.3390/s140406758>)

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Spatial%20estimation%20of%20sub-hour%20global%20horizontal%20irradiance%20based%20on%20official%20observations%20and%20remote%20sensors&author=FV.%20Gutierrez-Corea&author=MA.%20Manso-Callejo&author=MP.%20Moreno-Regidor&author=J.%20Velasco-G%C3%B3mez&journal=Sensors&volume=14&pages=6758-6787&publication\\_year=2014](http://scholar.google.com/scholar_lookup?title=Spatial%20estimation%20of%20sub-hour%20global%20horizontal%20irradiance%20based%20on%20official%20observations%20and%20remote%20sensors&author=FV.%20Gutierrez-Corea&author=MA.%20Manso-Callejo&author=MP.%20Moreno-Regidor&author=J.%20Velasco-G%C3%B3mez&journal=Sensors&volume=14&pages=6758-6787&publication_year=2014))

Habte A, Sengupta M, Gueymard C, Stoffel T (2017a) Solar resource data. In: Sengupta M, Habte A, Gueymard C, Wilbert S, Renné D (eds) *Best Practices Handbook for the Collection and Use of Solar Resource Data for Solar Energy Applications*, Second edn. NREL, Denver, pp 5.1–5.17

**Google Scholar** (<https://scholar.google.com/scholar?q=Habte%20A%20Sengupta%20M%20Gueymard%20C%20Stoffel%20T%20%282017a%29%20Solar%20resource%20data.%20In%3A%20Sengupta%20M%20Habte%20A%20Gueymard%20C%20Wilbert%20S%20Renn%C3%A9%20D%20%28eds%29%20Best%20Practices%20Handbook%20for%20the%20Collection%20and%20Use%20of%20Solar%20Resource%20Data%20for%20Solar%20Energy%20Applications%20Second%20edn.%20NREL%20Denver%20%20pp%205.1%E2%80%935.17>)

Habte A, Stoffel T, Perez R, Myers D, Gueymard C, Blanc P, Wilbert S (2017b) Overview of solar radiation resource concepts. In: Sengupta M, Habte A, Gueymard C, Wilbert S, Renné D (eds) *Best Practices Handbook for the Collection and Use of Solar Resource Data for Solar Energy Applications*, Second edn. NREL, Denver, pp 2.1–2.22

**Google Scholar** (<https://scholar.google.com/scholar?q=Habte%20A%20Stoffel%20T%20Perez%20R%20Myers%20D%20Gueymard%20C%20Blanc%20P%20Wilbert%20S%20%282017b%29%20Overview%20of%20solar%20radiation%20resource%20concepts.%20In%3A%20Sengupta%20M%20Habte%20A%20Gueymard%20C%20Wilbert%20S%20Renn>)



%C3%A9%20D%20%28eds%29%20Best%20Practices%20Handbook%20for%20the%20Collection%20and%20Use%20of%20Solar%20Resource%20Data%20for%20Solar%20Energy%20Applications%2C%20Second%20edn.%20NREL%2C%20Denver%2C%20pp%202.1%E2%80%932.22)

Hay JE (1979) Calculation of monthly mean solar radiation for horizontal and inclined surfaces. *Sol Energy* 23(4):301–307

[CrossRef](https://doi.org/10.1016/0038-092X(79)90123-3) (https://doi.org/10.1016/0038-092X(79)90123-3)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Calculation%20of%20monthly%20mean%20solar%20radiation%20for%20horizontal%20and%20inclined%20surfaces&author=JE.%20Hay&journal=Sol%20Energy&volume=23&issue=4&pages=301-307&publication_year=1979) (http://scholar.google.com/scholar\_lookup?title=Calculation%20of%20monthly%20mean%20solar%20radiation%20for%20horizontal%20and%20inclined%20surfaces&author=JE.%20Hay&journal=Sol%20Energy&volume=23&issue=4&pages=301-307&publication\_year=1979)

Jenks GF (1967) The data model concept in statistical mapping. *International Yearbook of Cartography* 7:186–190

[Google Scholar](http://scholar.google.com/scholar_lookup?title=The%20data%20model%20concept%20in%20statistical%20mapping&author=GF.%20Jenks&journal=International%20Yearbook%20of%20Cartography&volume=7&pages=186-190&publication_year=1967) (http://scholar.google.com/scholar\_lookup?title=The%20data%20model%20concept%20in%20statistical%20mapping&author=GF.%20Jenks&journal=International%20Yearbook%20of%20Cartography&volume=7&pages=186-190&publication\_year=1967)

Jerez S, Trigo RM (2013) Time-scale and extent at which large-scale circulation modes determine the wind and solar potential in the Iberian peninsula. *Environ Res Lett* 8(4):044035

[CrossRef](https://doi.org/10.1088/1748-9326/8/4/044035) (https://doi.org/10.1088/1748-9326/8/4/044035)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Time-scale%20and%20extent%20at%20which%20large-scale%20circulation%20modes%20determine%20the%20wind%20and%20solar%20potential%20in%20the%20Iberian%20openinsula&author=S.%20Jerez&author=RM.%20Trigo&journal=Environ%20Res%20Lett&volume=8&issue=4&publication_year=2013) (http://scholar.google.com/scholar\_lookup?title=Time-scale%20and%20extent%20at%20which%20large-scale%20circulation%20modes%20determine%20the%20wind%20and%20solar%20potential%20in%20the%20Iberian%20openinsula&author=S.%20Jerez&author=RM.%20Trigo&journal=Environ%20Res%20Lett&volume=8&issue=4&publication\_year=2013)

Kaiser DP, Qian Y (2002) Decreasing trends in sunshine duration over China for 1954–1998: indication of increased haze pollution? *Geophys Res Lett* 29(21):38.1–38.4

[CrossRef](https://doi.org/10.1029/2002GL016057) (https://doi.org/10.1029/2002GL016057)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Decreasing%20trends%20in%20sunshine%20duration%20over%20China%20for%201954%E2%80%931998%3A%20indication%20of%20increased%20haze%20pollution%3F&author=DP.%20Kaiser&author=Y.%20Qian&journal=Geophys%20Res%20Lett&volume=29&issue=21&pages=38.1-38.4&publication_year=2002) (http://scholar.google.com/scholar\_lookup?title=Decreasing%20trends%20in%20sunshine%20duration%20over%20China%20for%201954%E2%80%931998%3A%20indication%20of%20increased%20haze%20pollution%3F&author=DP.%20Kaiser&author=Y.%20Qian&journal=Geophys%20Res%20Lett&volume=29&issue=21&pages=38.1-38.4&publication\_year=2002)

Lave M, Kleissl J (2010) Solar variability of four sites across the state of Colorado. *Renew Energy* 35:2867–2873

[CrossRef](https://doi.org/10.1016/j.renene.2010.05.013) (https://doi.org/10.1016/j.renene.2010.05.013)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Solar%20variability%20of%20four%20sites%20across%20the%20state%20of%20Colorado&author=M.%20Lave&author=J.%20Kleissl&journal=Renew%20Energy&volume=35&pages=2867-2873&publication_year=2010) (http://scholar.google.com/scholar\_lookup?title=Solar%20variability%20of%20four%20sites%20across%20the%20state%20of%20Colorado&author=M.%20Lave&author=J.%20Kleissl&journal=Renew%20Energy&volume=35&pages=2867-2873&publication\_year=2010)

Löf GO, Duffie JA, Smith CO (1966) World distribution of solar radiation. *Sol Energy* 10(1):27–37

[CrossRef](https://doi.org/10.1016/0038-092X(66)90069-7) (https://doi.org/10.1016/0038-092X(66)90069-7)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=World%20distribution%20of%20solar%20radiation&author=GO.%20L%C3%B6f&author=JA.%20Duffie&author=CO.%20Smith&journal=Sol%20Energy&volume=10&issue=1&pages=27-37&publication_year=1966) (http://scholar.google.com/scholar\_lookup?title=World%20distribution%20of%20solar%20radiation&author=GO.%20L%C3%B6f&author=JA.%20Duffie&author=CO.%20Smith&journal=Sol%20Energy&volume=10&issue=1&pages=27-37&publication\_year=1966)

Magee BN, Melaas E, Finocchio PM, Jardel M, Noonan A, Iacono MJ (2014) Blue hill observatory sunshine: assessment of climate signals in the longest continuous meteorological record in North America. *Bull Am Meteorol Soc* 95(11):1741–1751

[CrossRef](https://doi.org/10.1175/BAMS-D-12-00206.1) (https://doi.org/10.1175/BAMS-D-12-00206.1)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Blue%20hill%20observatory%20sunshine%3A%20assessment%20of%20climate%20signals%20in%20the%20longest%20continuous%20meteorological%20record%20in%20North%20America&author=BN.%20Magee&author=E.%20Melaas&author=PM.%20Finocchio&author=M.%20Jardel&author=A.%20Noonan&author=MJ.%20Iacono&journal=Bull%20Am%20Meteorol%20Soc&volume=95&issue=11&pages=1741-1751&publication_year=2014) (http://scholar.google.com/scholar\_lookup?title=Blue%20hill%20observatory%20sunshine%3A%20assessment%20of%20climate%20signals%20in%20the%20longest%20continuous%20meteorological%20record%20in%20North%20America&author=BN.%20Magee&author=E.%20Melaas&author=PM.%20Finocchio&author=M.%20Jardel&author=A.%20Noonan&author=MJ.%20Iacono&journal=Bull%20Am%20Meteorol%20Soc&volume=95&issue=11&pages=1741-1751&publication\_year=2014)

Manara V, Beltrano MC, Brunetti M, Maugeri M, Sanchez-Lorenzo A, Simolo C, Sorrenti S (2015) Sunshine duration variability and trends in Italy from homogenized instrumental time series (1936–2013). *Journal of Geophysical Research: Atmospheres* 120(9):3622–3641

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Sunshine%20duration%20variability%20and%20trends%20in%20Italy%20from%20homogenized%20instrumental%20time%20series%20%281936%E2%80%932013%29&author=V.%20Manara&author=MC.%20Beltrano&author=M.%20Brunetti&author=M.%20Maugeri&author=A.%20Sanchez-Lorenzo&author=C.%20Simolo&author=S.%20Sorrenti&journal=Journal%20of%20Geophysical%20Research%3A%20Atmospheres&volume=120&issue=9&pages=3622-3641&publication_year=2015) (http://scholar.google.com/scholar\_lookup?title=Sunshine%20duration%20variability%20and%20trends%20in%20Italy%20from%20homogenized%20instrumental%20time%20series%20%281936%E2%80%932013%29&author=V.%20Manara&author=MC.%20Beltrano&author=M.%20Brunetti&author=M.%20Maugeri&author=A.%20Sanchez-Lorenzo&author=C.%20Simolo&author=S.%20Sorrenti&journal=Journal%20of%20Geophysical%20Research%3A%20Atmospheres&volume=120&issue=9&pages=3622-3641&publication\_year=2015)

Martins FR, Pereira EB, Silva SAB, Abreu SL, Colle S (2008) Solar energy scenarios in Brazil, part one: resource assessment. *Energy Policy* 36(8):2853–2864

[CrossRef](https://doi.org/10.1016/j.enpol.2008.02.014) (https://doi.org/10.1016/j.enpol.2008.02.014)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Solar%20energy%20scenarios%20in%20Brazil%2C%20part%20one%3A%20resource%20assessment&author=FR.%20Martins&author=EB.%20Pereira&author=SAB.%20Silva&author=SL.%20Abreu&author=S.%20Colle&journal=Energy%20Policy&volume=36&issue=8&pages=2853-2864&publication_year=2008) (http://scholar.google.com/scholar\_lookup?title=Solar%20energy%20scenarios%20in%20Brazil%2C%20part%20one%3A%20resource%20assessment&author=FR.%20Martins&author=EB.%20Pereira&author=SAB.%20Silva&author=SL.%20Abreu&author=S.%20Colle&journal=Energy%20Policy&volume=36&issue=8&pages=2853-2864&publication\_year=2008)

Matuszko D (2012) Influence of cloudiness on sunshine duration. *Int J Climatol* 32(10):1527–1536

[CrossRef](https://doi.org/10.1002/joc.2370) (https://doi.org/10.1002/joc.2370)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Influence%20of%20cloudiness%20on%20sunshine%20duration&author=D.%20Matuszko&journal=Int%20J%20Climatol&volume=32&issue=10&pages=1527-1536&publication_year=2012) (http://scholar.google.com/scholar\_lookup?title=Influence%20of%20cloudiness%20on%20sunshine%20duration&author=D.%20Matuszko&journal=Int%20J%20Climatol&volume=32&issue=10&pages=1527-1536&publication\_year=2012)

Matuszko D (2014) Long-term variability in solar radiation in Krakow based on measurements of sunshine duration. *Int J Climatol* 34:228–234

[CrossRef](https://doi.org/10.1002/joc.3681) (https://doi.org/10.1002/joc.3681)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Long-term%20variability%20in%20solar%20radiation%20in%20Krakow%20based%20on%20measurements%20of%20sunshine%20duration&author=D.%20Matuszko&journal=Int%20J%20Climatol&volume=34&pages=228-234&publication_year=2014) (http://scholar.google.com/scholar\_lookup?title=Long-term%20variability%20in%20solar%20radiation%20in%20Krakow%20based%20on%20measurements%20of%20sunshine%20duration&author=D.%20Matuszko&journal=Int%20J%20Climatol&volume=34&pages=228-234&publication\_year=2014)

Matuszko D (2015) A comparison of sunshine duration records from the Campbell-stokes sunshine recorder and CSD3 sunshine duration sensor. *Theor Appl Climatol* 119(3–4):401–406

**CrossRef** (<https://doi.org/10.1007/s00704-014-1125-z>)

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=A%20comparison%20of%20sunshine%20duration%20records%20from%20the%20Campbell-stokes%20sunshine%20recorder%20and%20CSD3%20sunshine%20duration%20sensor&author=D.%20Matuszko&journal=Theor%20Appl%20Climatol&volume=119&issue=3%E2%80%934&pages=401-406&publication\\_year=2015](http://scholar.google.com/scholar_lookup?title=A%20comparison%20of%20sunshine%20duration%20records%20from%20the%20Campbell-stokes%20sunshine%20recorder%20and%20CSD3%20sunshine%20duration%20sensor&author=D.%20Matuszko&journal=Theor%20Appl%20Climatol&volume=119&issue=3%E2%80%934&pages=401-406&publication_year=2015))

Mecibah MS, Boukelia TE, Tahtah R, Gairaa K (2014) Introducing the best model for estimation of the monthly mean daily global solar radiation on a horizontal surface (case study: Algeria). *Renew Sust Energ Rev* 36:194–202

**Google Scholar** (<https://scholar.google.com/scholar?q=Mecibah%20MS%2C%20Boukelia%20TE%2C%20Tahtah%20R%2C%20Gairaa%20K%20%282014%29%20Introducing%20the%20best%20model%20for%20estimation%20of%20the%20monthly%20mean%20daily%20global%20solar%20radiation%20on%20a%20horizontal%20surface%20%28case%20study%3A%20Algeria%29.%20Renew%20Sust%20Energ%20Rev%2036%3A194%E2%80%93202>)

Meyer R, Sengupta M (2017) Why solar resource data are important to solar power. In: Sengupta M, Habte A, Gueymard C, Wilbert S, Renné D (eds) *Best Practices Handbook for the Collection and Use of Solar Resource Data for Solar Energy Applications*, Second edn. NREL, Denver, pp 1.1–1.3

**Google Scholar** (<https://scholar.google.com/scholar?q=Meyer%20R%2C%20Sengupta%20M%20%282017%29%20Why%20solar%20resourc%20data%20are%20important%20to%20solar%20power.%20In%3A%20Sengupta%20M%2C%20Habte%20A%2C%20Gueymard%20C%2C%20Wilbert%20S%2C%20Renn%C3%A9%20D%20%28eds%29%20Best%20Practices%20Handbook%20for%20the%20Collection%20and%20Use%20of%20Solar%20Resource%20Data%20for%20Solar%20Energy%20Applications%2C%20Second%20edn.%20NREL%2C%20Denver%2C%20pp%201.1%E2%80%931.3>)

Muzathik AM, Nik WBW, Ibrahim MZ, Samo KB, Sopian K, Alghoul MA (2011) Daily global solar radiation estimate based on sunshine hours. *International Journal of Mechanical and Mater Eng* 6(1):75–80

**Google Scholar** (<https://scholar.google.com/scholar?q=Muzathik%20AM%2C%20Nik%20WBW%2C%20Ibrahim%20MZ%2C%20Samo%20KB%2C%20Sopian%20K%2C%20Alghoul%20MA%20%282011%29%20Daily%20global%20solar%20radiation%20estimate%20based%20on%20sunshine%20hours.%20Intern%20ational%20Journal%20of%20Mechanical%20and%20Mater%20Eng%206%281%29%3A75%E2%80%9380>)

Nguyen BT, Pryor TL (1997) The relationship between global solar radiation and sunshine duration in Vietnam. *Renew Energy* 11(1):47–60

**Google Scholar** (<https://scholar.google.com/scholar?q=Nguyen%20BT%2C%20Pryor%20TL%20%281997%29%20The%20relationship%20bet%20ween%20global%20solar%20radiation%20and%20sunshine%20duration%20in%20Vi%20etnam.%20Renew%20Energy%2011%281%29%3A47%E2%80%9360>)

Nikitidou E, Tzoumanikas P, Bais AF, Kazantzidis A (2017) The effect of clouds on surface solar irradiance, from an all-sky camera, in Thessaloniki, Greece. In: Karavostas T, Bais A, Nastos P (eds) *Perspectives on Atmospheric Sciences*. Springer, Cham, pp 1157–1162

**Google Scholar** (<https://scholar.google.com/scholar?>

q=Nikitidou%20E%2C%20Tzoumanikas%20P%2C%20Bais%20AF%2C%20Kazantzidis%20A%20%282017%29%20The%20effect%20of%20clouds%20on%20surface%20solar%20irradiance%2C%20from%20an%20all-sky%20camera%2C%20in%20Thessaloniki%2C%20Greece.%20In%3A%20Karavostas%20T%2C%20Bais%20A%2C%20Nastos%20P%20%28eds%29%20Perspectives%20on%20Atmospheric%20Sciences.%20Springer%2C%20Cham%2C%20pp%201157%E2%80%9331162)

Novau JC, Campo JF (1995) Irregularidad pluviométrica y continentalidad térmica en el valle medio del Ebro. *Lucas Mallada Revista de. Ciencias* 7:147–164

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?](http://scholar.google.com/scholar_lookup?)

title=Irregularidad%20pluviom%C3%A9trica%20y%20continentalidad%20t%C3%A9rmica%20en%20el%20valle%20medio%20del%20Ebro.%20Lucas%20Mallada%20Revista%20de&author=JC.%20Novau&author=JF.%20Campo&journal=Ciencias&volume=7&pages=147-164&publication\_year=1995)

Painter HE (1981) The performance of a Campbell-Stokes sunshine recorder compared with a simultaneous record of normal incidence irradiance. *Meteorology Magazine*

110:102–109

**Google Scholar** (<https://scholar.google.com/scholar?>

q=Painter%20HE%20%281981%29%20The%20performance%20of%20a%20Campbell-Stokes%20sunshine%20recorder%20compared%20with%20a%20simultaneous%20record%20of%20normal%20incidence%20irradiance.%20Meteorology%20Magazine%20110%3A102%E2%80%93109)

Paruelo JM, Beltran JE, Sala OE, Golluscio RA (1998) The climate of Patagonia: general patterns and controls on biotic processes. *Ecol Austral* 8(2):85–101

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?](http://scholar.google.com/scholar_lookup?)

title=The%20climate%20of%20Patagonia%3A%20general%20patterns%20and%20controls%20on%20biotic%20processes&author=JM.%20Paruelo&author=JE.%20Beltran&author=OE.%20Sala&author=RA.%20Golluscio&journal=Ecol%20Austral&volume=8&issue=2&pages=85-101&publication\_year=1998)

Perez R, David M, Hoff TE, Jamaly M, Kivalov S, Kleissl J, Lauret P, Perez M (2016) Spatial and temporal variability of solar energy. *Foundations and Trends® in Renewable Energy* 1(1):1–44

**CrossRef** (<https://doi.org/10.1561/2700000006>)

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?](http://scholar.google.com/scholar_lookup?)

title=Spatial%20and%20temporal%20variability%20of%20solar%20energy&author=R.%20Perez&author=M.%20David&author=TE.%20Hoff&author=M.%20Jamaly&author=S.%20Kivalov&author=J.%20Kleissl&author=P.%20Lauret&author=M.%20Perez&journal=Foundations%20and%20Trends%20in%20Renewable%20Energy&volume=1&issue=1&pages=1-44&publication\_year=2016)

Perez R, Hoff T, Kivalov S (2011) Spatial & temporal characteristics of solar radiation variability. In: *Proc. of International Solar Energy (ISES) World Congress*. ISES, Kassel

**Google Scholar** (<https://scholar.google.com/scholar?>

q=Perez%20R%2C%20Hoff%20T%2C%20Kivalov%20S%20%282011%29%20Spatial%20%26%20temporal%20characteristics%20of%20solar%20radiation%20variability.%20In%3A%20Proc.%20of%20International%20Solar%20Energy%20%28ISES%29%20World%20Congress.%20ISES%2C%20Kassel)

Perez R, Seals R, Zelenka A (1997) Comparing satellite remote sensing and ground network measurements for the production of site/time specific irradiance data. *Sol Energy* 60:89–96

[CrossRef](https://doi.org/10.1016/S0038-092X(96)00162-4) (https://doi.org/10.1016/S0038-092X(96)00162-4)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Comparing%20satellite%20remote%20sensing%20and%20ground%20network%20measurements%20for%20the%20production%20of%20site%20time%20specific%20irradiance%20data&author=R.%20Perez&author=R.%20Seals&author=A.%20Zelenka&journal=Sol%20Energy&volume=60&pages=89-96&publication_year=1997) (http://scholar.google.com/scholar\_lookup?title=Comparing%20satellite%20remote%20sensing%20and%20ground%20network%20measurements%20for%20the%20production%20of%20site%20time%20specific%20irradiance%20data&author=R.%20Perez&author=R.%20Seals&author=A.%20Zelenka&journal=Sol%20Energy&volume=60&pages=89-96&publication\_year=1997)

Pizarro H, Rodríguez P, Bonaventura SM, O'Farrell I, Izaguirre I (2007) The sudestadas: a hydro-meteorological phenomenon that affects river pollution (river Luján, South America). *Hydrol Sci J* 52(4):702–712

[CrossRef](https://doi.org/10.1623/hysj.52.4.702) (https://doi.org/10.1623/hysj.52.4.702)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=The%20sudestadas%3A%20a%20hydro-meteorological%20phenomenon%20that%20affects%20river%20pollution%20%28river%20Luj%C3%A1n%2C%20South%20America%29&author=H.%20Pizarro&author=P.%20Rodr%C3%ADguez&author=SM.%20Bonaventura&author=I.%20O%27Farrell&author=I.%20Izaguirre&journal=Hydrol%20Sci%20J&volume=52&issue=4&pages=702-712&publication_year=2007) (http://scholar.google.com/scholar\_lookup?title=The%20sudestadas%3A%20a%20hydro-meteorological%20phenomenon%20that%20affects%20river%20pollution%20%28river%20Luj%C3%A1n%2C%20South%20America%29&author=H.%20Pizarro&author=P.%20Rodr%C3%ADguez&author=SM.%20Bonaventura&author=I.%20O%27Farrell&author=I.%20Izaguirre&journal=Hydrol%20Sci%20J&volume=52&issue=4&pages=702-712&publication\_year=2007)

Power HC, Mills DM (2005) Solar radiation climate change over southern Africa and an assessment of the radiative impact of volcanic eruptions. *Int J Climatol* 25(3):295–318

[CrossRef](https://doi.org/10.1002/joc.1134) (https://doi.org/10.1002/joc.1134)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Solar%20radiation%20climate%20change%20over%20southern%20Africa%20and%20an%20assessment%20of%20the%20radiative%20impact%20of%20volcanic%20eruptions&author=HC.%20Power&author=DM.%20Mills&journal=Int%20J%20Climatol&volume=25&issue=3&pages=295-318&publication_year=2005) (http://scholar.google.com/scholar\_lookup?title=Solar%20radiation%20climate%20change%20over%20southern%20Africa%20and%20an%20assessment%20of%20the%20radiative%20impact%20of%20volcanic%20eruptions&author=HC.%20Power&author=DM.%20Mills&journal=Int%20J%20Climatol&volume=25&issue=3&pages=295-318&publication\_year=2005)

Pozo-Vázquez D, Tovar-Pescador J, Gámiz-Fortis SR, Esteban-Parra MJ, Castro-Díez Y (2004) NAO and solar radiation variability in the European North Atlantic region. *Geophys Res Lett* 31(5): L05201

[Google Scholar](https://scholar.google.com/scholar?q=Pozo-V%C3%A1zquez%20D%2C%20Tovar-Pescador%20J%2C%20G%C3%A1miz-Fortis%20SR%2C%20Esteban-Parra%20MJ%2C%20Castro-D%C3%ADez%20Y%20%282004%29%20NAO%20and%20solar%20radiation%20variability%20in%20the%20European%20North%20Atlantic%20region.%20Geophys%20Res%20Lett%2031%285%29%3A%20L05201) (https://scholar.google.com/scholar?q=Pozo-V%C3%A1zquez%20D%2C%20Tovar-Pescador%20J%2C%20G%C3%A1miz-Fortis%20SR%2C%20Esteban-Parra%20MJ%2C%20Castro-D%C3%ADez%20Y%20%282004%29%20NAO%20and%20solar%20radiation%20variability%20in%20the%20European%20North%20Atlantic%20region.%20Geophys%20Res%20Lett%2031%285%29%3A%20L05201)

Prohaska F (1976) The climate of Argentina, Paraguay and Uruguay. *Climates of Central and South America* 12:113–112

[Google Scholar](http://scholar.google.com/scholar_lookup?title=The%20climate%20of%20Argentina%2C%20Paraguay%20and%20Uruguay&author=F.%20Prohaska&journal=Climates%20of%20Central%20and%20South%20America&volume=12&pages=113-112&publication_year=1976) (http://scholar.google.com/scholar\_lookup?title=The%20climate%20of%20Argentina%2C%20Paraguay%20and%20Uruguay&author=F.%20Prohaska&journal=Climates%20of%20Central%20and%20South%20America&volume=12&pages=113-112&publication\_year=1976)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=The%20climate%20of%20Argentina%2C%20Paraguay%20and%20Uruguay&author=F.%20Prohaska&journal=Climates%20of%20Central%20and%20South%20America&volume=12&pages=113-112&publication_year=1976) (http://scholar.google.com/scholar\_lookup?title=The%20climate%20of%20Argentina%2C%20Paraguay%20and%20Uruguay&author=F.%20Prohaska&journal=Climates%20of%20Central%20and%20South%20America&volume=12&pages=113-112&publication\_year=1976)

Raichijk C (2012) Observed trends in sunshine duration over South America. *Int J Climatol* 32:669–680

[CrossRef](https://doi.org/10.1002/joc.2296) (https://doi.org/10.1002/joc.2296)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Observed%20trends%20in%20sunshine%20duration%20over%20South%20Ameri) (http://scholar.google.com/scholar\_lookup?title=Observed%20trends%20in%20sunshine%20duration%20over%20South%20Ameri

ca&author=C.%20Raichijk&journal=Int%20J%20Climatol&volume=32&pages=669-680&publication\_year=2012)

**Raichijk C, Grossi Gallegos H, Righini R (2006a) Análisis de los datos de heliofanía en la República Oriental del Uruguay. Avances en Energías Renovables y Medio Ambiente 8: 11.101–11.105**

**Google Scholar** (<https://scholar.google.com/scholar?q=Raichijk%20C%20Grossi%20Gallegos%20H%20Righini%20R%20%282006a%29%20An%20C%20A%20lisis%20de%20los%20datos%20de%20heliofan%20en%20la%20Rep%20B%20lica%20Oriental%20del%20Uruguay.%20Avances%20en%20Energ%20C%20A%20Renovables%20y%20Medio%20Ambiente%208%3A%2011.101%20-%2011.105>)

**Raichijk C, Grossi Gallegos H, Righini R (2006b) Variabilidad espacial de la heliofanía (duración de la insolación) en la Pampa Húmeda argentina, Uruguay y sur del Brasil. Energías Renovables y Medio Ambiente 19:33–37**

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Variabilidad%20espacial%20de%20la%20heliofan%20en%20la%20Pampa%20H%20meda%20argentina%20C%20Uruguay%20y%20sur%20del%20Brasil&author=C.%20Raichijk&author=H.%20Grossi&author=R.%20Righini&journal=Energ%20C%20A%20Renovables%20y%20Medio%20Ambiente&volume=19&pages=33-37&publication\\_year=2006](http://scholar.google.com/scholar_lookup?title=Variabilidad%20espacial%20de%20la%20heliofan%20en%20la%20Pampa%20H%20meda%20argentina%20C%20Uruguay%20y%20sur%20del%20Brasil&author=C.%20Raichijk&author=H.%20Grossi&author=R.%20Righini&journal=Energ%20C%20A%20Renovables%20y%20Medio%20Ambiente&volume=19&pages=33-37&publication_year=2006))

**Roccatagliata JA (2008) La Pampa Bonaerense y sus extensiones. In: Roccatagliata J (ed) Argentina: una visión actual y prospectiva desde la dimensión territorial. Emecé Editores. Buenos Aires:643–712**

**Google Scholar** (<https://scholar.google.com/scholar?q=Roccatagliata%20JA%20%282008%29%20La%20Pampa%20Bonaerense%20y%20sus%20extensiones.%20In%20Roccatagliata%20J%20%28ed%29%20Argentina%20una%20visi%20n%20actual%20y%20prospectiva%20desde%20la%20dimensi%20n%20territorial.%20Emec%20Editores.%20Buenos%20Aires%20643%20-%20712>)

**Roman R, Bilbao J, De Miguel A (2014) Reconstruction of six decades of daily total solar shortwave irradiation in the Iberian peninsula using sunshine duration records. Atmos Environ 99:41–50**

**CrossRef** (<https://doi.org/10.1016/j.atmosenv.2014.09.052>)  
**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Reconstruction%20of%20six%20decades%20of%20daily%20total%20solar%20shortwave%20irradiation%20in%20the%20Iberian%20peninsula%20using%20sunshine%20duration%20records&author=R.%20Roman&author=J.%20Bilbao&author=A.%20Miguel&journal=Atmos%20Environ&volume=99&pages=41-50&publication\\_year=2014](http://scholar.google.com/scholar_lookup?title=Reconstruction%20of%20six%20decades%20of%20daily%20total%20solar%20shortwave%20irradiation%20in%20the%20Iberian%20peninsula%20using%20sunshine%20duration%20records&author=R.%20Roman&author=J.%20Bilbao&author=A.%20Miguel&journal=Atmos%20Environ&volume=99&pages=41-50&publication_year=2014))

**Sala Sanjaume M, Batalla Villanueva R (1996) Teoría y métodos en Geografía Física. Editorial Síntesis, Madrid**

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Teor%20a%20y%20m%20todos%20en%20Geograf%20a%20f%20sica&author=M.%20Sala%20Sanjaume&author=R.%20Batalla%20Villanueva&publication\\_year=1996](http://scholar.google.com/scholar_lookup?title=Teor%20a%20y%20m%20todos%20en%20Geograf%20a%20f%20sica&author=M.%20Sala%20Sanjaume&author=R.%20Batalla%20Villanueva&publication_year=1996))

**Sánchez G, Serrano A, Cancillo ML (2012) Effect of cloudiness on solar global, solar diffuse and terrestrial downward radiation at Badajoz (southwestern Spain). Óptica Pura y Aplicada 45:33–38**

**CrossRef** (<https://doi.org/10.7149/OPA.45.1.33>)

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Effect%20of%20cloudiness%20on%20solar%20global%2C%20solar%20diffuse%20and%20terrestrial%20downward%20radiation%20at%20Badajoz%20%28southwestern%20Spain%29&author=G.%20S%2C%2A1nchez&author=A.%20Serrano&author=ML.%20Cancillo&journal=%2C%293ptica%20Pura%20y%20Aplicada&volume=45&pages=33-38&publication\\_year=2012](http://scholar.google.com/scholar_lookup?title=Effect%20of%20cloudiness%20on%20solar%20global%2C%20solar%20diffuse%20and%20terrestrial%20downward%20radiation%20at%20Badajoz%20%28southwestern%20Spain%29&author=G.%20S%2C%2A1nchez&author=A.%20Serrano&author=ML.%20Cancillo&journal=%2C%293ptica%20Pura%20y%20Aplicada&volume=45&pages=33-38&publication_year=2012))

**Sanchez-Lorenzo A, Calbo J, and J. Martine-Vide J (2008) Spatial and temporal trends in sunshine duration over Western Europe (1938–2004). *J Clim* 21: 6089–6098**

**Google Scholar** (<https://scholar.google.com/scholar?q=Sanchez-Lorenzo%20A%2C%20Calbo%20J%2C%20and%20J.%20Martine-Vide%20J%20%282008%29%20Spatial%20and%20temporal%20trends%20in%20sunshine%20duration%20over%20Western%20Europe%20%281938%E2%80%932004%29.%20J%20Clim%2021%3A%206089%E2%80%936098>)

**Sánchez-Romero A, Sanchez-Lorenzo A, Calbó J, González JA, Azorin-Molina C (2014) The signal of aerosol-induced changes in sunshine duration records: a review of the evidence. *Journal of Geophysical Research: Atmospheres* 119(8):4657–4673**

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=The%20signal%20of%20aerosol-induced%20changes%20in%20sunshine%20duration%20records%3A%20a%20review%20of%20the%20evidence&author=A.%20S%2C%2A1nchez-Romero&author=A.%20Sanchez-Lorenzo&author=J.%20Calb%2C%2B3&author=JA.%20Gonz%2C%2A1lez&author=C.%20Azorin-Molina&journal=Journal%20of%20Geophysical%20Research%3A%20Atmospheres&volume=119&issue=8&pages=4657-4673&publication\\_year=2014](http://scholar.google.com/scholar_lookup?title=The%20signal%20of%20aerosol-induced%20changes%20in%20sunshine%20duration%20records%3A%20a%20review%20of%20the%20evidence&author=A.%20S%2C%2A1nchez-Romero&author=A.%20Sanchez-Lorenzo&author=J.%20Calb%2C%2B3&author=JA.%20Gonz%2C%2A1lez&author=C.%20Azorin-Molina&journal=Journal%20of%20Geophysical%20Research%3A%20Atmospheres&volume=119&issue=8&pages=4657-4673&publication_year=2014))

**Şen Z, ŞahİN AD (2001) Spatial interpolation and estimation of solar irradiation by cumulative semivariograms. *Sol Energy* 71:11–21**

**CrossRef** ([https://doi.org/10.1016/S0038-092X\(01\)00009-3](https://doi.org/10.1016/S0038-092X(01)00009-3))  
**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Spatial%20interpolation%20and%20estimation%20of%20solar%20irradiation%20by%20cumulative%20semivariograms&author=Z.%20%2C%29Een&author=AD.%20%2C%29Eah%2C%2B0n&journal=Sol%20Energy&volume=71&pages=11-21&publication\\_year=2001](http://scholar.google.com/scholar_lookup?title=Spatial%20interpolation%20and%20estimation%20of%20solar%20irradiation%20by%20cumulative%20semivariograms&author=Z.%20%2C%29Een&author=AD.%20%2C%29Eah%2C%2B0n&journal=Sol%20Energy&volume=71&pages=11-21&publication_year=2001))

**Sengupta M, Polo J, Gueymard C, Xie Y (2017) Modeling solar radiation—current practices. In: Sengupta M, Habte A, Gueymard C, Wilbert S, Renné D (eds) *Best Practices Handbook for the Collection and Use of Solar Resource Data for Solar Energy Applications*, Second edn. NREL, Denver, pp 4.1–4.28**

**Google Scholar** (<https://scholar.google.com/scholar?q=Sengupta%20M%2C%20Polo%20J%2C%20Gueymard%20C%2C%20Xie%20Y%20%282017%29%20Modeling%20solar%20radiation%E2%80%94current%20practices.%20In%3A%20Sengupta%20M%2C%20Habte%20A%2C%20Gueymard%20C%2C%20Wilbert%20S%2C%20Renn%C3%A9%20D%20%28eds%29%20Best%20Practices%20Handbook%20for%20the%20Collection%20and%20Use%20of%20Solar%20Resource%20Data%20for%20Solar%20Energy%20Applications%2C%20Second%20edn.%20NREL%2C%20Denver%2C%20pp%204.1%E2%80%934.28>)

**Servicio Meteorológico Nacional (2003) Estadísticas Climatológicas: 1991–2000. Servicio Meteorológico Nacional, Buenos Aires**

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Estad%C3%ADsticas%20Climatol%C3%B3gicas%3A%201991%E2%80%932000&publication\\_year=2003](http://scholar.google.com/scholar_lookup?title=Estad%C3%ADsticas%20Climatol%C3%B3gicas%3A%201991%E2%80%932000&publication_year=2003))

Servicio Meteorológico Nacional (2011) Estadísticas climatológicas: 2001–2010. Servicio Meteorológico Nacional, Buenos Aires

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Estad%C3%ADsticas%20climatol%C3%B3gicas%3A%202001%E2%80%932010&publication\\_year=2011](http://scholar.google.com/scholar_lookup?title=Estad%C3%ADsticas%20climatol%C3%B3gicas%3A%202001%E2%80%932010&publication_year=2011))

Srivastava SK, Singh OP, Pandey GN (1993) Estimation of global solar radiation in Uttar Pradesh (India) and comparison of some existing correlations. *Sol Energy* 51(1):27–29

**CrossRef** ([https://doi.org/10.1016/0038-092X\(93\)90038-P](https://doi.org/10.1016/0038-092X(93)90038-P))

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Estimation%20of%20global%20solar%20radiation%20in%20Uttar%20Pradesh%20%28India%29%20and%20comparison%20of%20some%20existing%20correlations&author=SK.%20Srivastava&author=OP.%20Singh&author=GN.%20Pandey&journal=Sol%20Energy&volume=51&issue=1&pages=27-29&publication\\_year=1993](http://scholar.google.com/scholar_lookup?title=Estimation%20of%20global%20solar%20radiation%20in%20Uttar%20Pradesh%20%28India%29%20and%20comparison%20of%20some%20existing%20correlations&author=SK.%20Srivastava&author=OP.%20Singh&author=GN.%20Pandey&journal=Sol%20Energy&volume=51&issue=1&pages=27-29&publication_year=1993))

Stanhill G (1998) Estimation of direct solar beam irradiance from measurements of the duration of bright sunshine. *Int J Climatol* 18(3):347–354

**CrossRef** ([https://doi.org/10.1002/\(SICI\)1097-0088\(19980315\)18%3A3<347%3A%3AAID-JOC239>3.0.CO%3B2-O](https://doi.org/10.1002/(SICI)1097-0088(19980315)18%3A3<347%3A%3AAID-JOC239>3.0.CO%3B2-O))

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Estimation%20of%20direct%20solar%20beam%20irradiance%20from%20measurements%20of%20the%20duration%20of%20bright%20sunshine&author=G.%20Stanhill&journal=Int%20J%20Climatol&volume=18&issue=3&pages=347-354&publication\\_year=1998](http://scholar.google.com/scholar_lookup?title=Estimation%20of%20direct%20solar%20beam%20irradiance%20from%20measurements%20of%20the%20duration%20of%20bright%20sunshine&author=G.%20Stanhill&journal=Int%20J%20Climatol&volume=18&issue=3&pages=347-354&publication_year=1998))

Stanhill G (2003) Through a glass brightly: some new light on the Campbell–Stokes sunshine recorder. *Weather* 58:3–11

**Google Scholar** (<https://scholar.google.com/scholar?q=Stanhill%20G%20%282003%29%20Through%20a%20glass%20brightly%3A%20some%20new%20light%20on%20the%20Campbell%E2%80%93Stokes%20sunshine%20recorder.%20Weather%2058%3A3%E2%80%9311>)

Stanhill G, Cohen S (2005) Solar radiation changes in United States during the twentieth century: evidence from sunshine duration measurements. *J Clim* 18:1503–1512.

<https://doi.org/10.1175/JCLI3354.1> (<https://doi.org/10.1175/JCLI3354.1>)

**CrossRef** (<https://doi.org/10.1175/JCLI3354.1>)

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Solar%20radiation%20changes%20in%20United%20States%20during%20the%20twentieth%20century%3A%20evidence%20from%20sunshine%20duration%20measurements&author=G.%20Stanhill&author=S.%20Cohen&journal=J%20Clim&volume=18&pages=1503-1512&publication\\_year=2005&doi=10.1175%2FJCLI3354.1](http://scholar.google.com/scholar_lookup?title=Solar%20radiation%20changes%20in%20United%20States%20during%20the%20twentieth%20century%3A%20evidence%20from%20sunshine%20duration%20measurements&author=G.%20Stanhill&author=S.%20Cohen&journal=J%20Clim&volume=18&pages=1503-1512&publication_year=2005&doi=10.1175%2FJCLI3354.1))

Stanhill G, Cohen S (2008) Solar radiation changes in Japan during the 20th century: evidence from sunshine duration measurements. *Journal of the Meteorological Society of Japan*. Ser II 86(1):57–67. <https://doi.org/10.2151/jmsj.86.57>

(<https://doi.org/10.2151/jmsj.86.57>)

Strahler A, Strahler A (2005) *Geografía Física*. Omega, Barcelona

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Geograf%C3%ADa%20F%C3%ADsica&author=A.%20Strahler&author=A.%20Stra](http://scholar.google.com/scholar_lookup?title=Geograf%C3%ADa%20F%C3%ADsica&author=A.%20Strahler&author=A.%20Stra)



hler&publication\_year=2005)

Tarawneh QY (2018) Harmonic analysis of solar irradiation and rainfall data in the context of various climatic indicators in Saudi Arabia. *Arab J Geosci* 11(4):75

[CrossRef](https://doi.org/10.1007/s12517-018-3414-9) (https://doi.org/10.1007/s12517-018-3414-9)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Harmonic%20analysis%20of%20solar%20irradiation%20and%20rainfall%20data%20in%20the%20context%20of%20various%20climatic%20indicators%20in%20Saudi%20Arabia&author=QY.%20Tarawneh&journal=Arab%20J%20Geosci&volume=11&issue=4&pages=75&publication_year=2018) (http://scholar.google.com/scholar\_lookup?

title=Harmonic%20analysis%20of%20solar%20irradiation%20and%20rainfall%20data%20in%20the%20context%20of%20various%20climatic%20indicators%20in%20Saudi%20Arabia&author=QY.%20Tarawneh&journal=Arab%20J%20Geosci&volume=11&issue=4&pages=75&publication\_year=2018)

Tarawneh QY, El Alfy M (2017) Seasonal variation of solar irradiance and sunshine duration in Saudi Arabia. *Int J Environ Sci Technol* 14:1267–1276

[CrossRef](https://doi.org/10.1007/s13762-016-1230-x) (https://doi.org/10.1007/s13762-016-1230-x)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Seasonal%20variation%20of%20solar%20irradiance%20and%20sunshine%20duration%20in%20Saudi%20Arabia&author=QY.%20Tarawneh&author=M.%20Alfy&journal=Int%20J%20Environ%20Sci%20Technol&volume=14&pages=1267-1276&publication_year=2017) (http://scholar.google.com/scholar\_lookup?

title=Seasonal%20variation%20of%20solar%20irradiance%20and%20sunshine%20duration%20in%20Saudi%20Arabia&author=QY.%20Tarawneh&author=M.%20Alfy&journal=Int%20J%20Environ%20Sci%20Technol&volume=14&pages=1267-1276&publication\_year=2017)

Tomson T, Hansen M (2010) Fast changes of the solar irradiance. *Estonian Journal of Engineering* 16:176–183

[CrossRef](https://doi.org/10.3176/eng.2010.2.06) (https://doi.org/10.3176/eng.2010.2.06)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Fast%20changes%20of%20the%20solar%20irradiance&author=T.%20Tomson&author=M.%20Hansen&journal=Estonian%20Journal%20of%20Engineering&volume=16&pages=176-183&publication_year=2010) (http://scholar.google.com/scholar\_lookup?

title=Fast%20changes%20of%20the%20solar%20irradiance&author=T.%20Tomson&author=M.%20Hansen&journal=Estonian%20Journal%20of%20Engineering&volume=16&pages=176-183&publication\_year=2010)

Tzoumanikas P, Nikitidou E, Bais AF, Kazantzidis A (2016) The effect of clouds on surface solar irradiance, based on data from an all-sky imaging system. *Renew Energy* 95:314–322

[CrossRef](https://doi.org/10.1016/j.renene.2016.04.026) (https://doi.org/10.1016/j.renene.2016.04.026)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=The%20effect%20of%20clouds%20on%20surface%20solar%20irradiance%2C%20based%20on%20data%20from%20an%20all-sky%20imaging%20system&author=P.%20Tzoumanikas&author=E.%20Nikitidou&author=AF.%20Bais&author=A.%20Kazantzidis&journal=Renew%20Energy&volume=95&pages=314-322&publication_year=2016) (http://scholar.google.com/scholar\_lookup?

title=The%20effect%20of%20clouds%20on%20surface%20solar%20irradiance%2C%20based%20on%20data%20from%20an%20all-sky%20imaging%20system&author=P.%20Tzoumanikas&author=E.%20Nikitidou&author=AF.%20Bais&author=A.%20Kazantzidis&journal=Renew%20Energy&volume=95&pages=314-322&publication\_year=2016)

Urban G, Migala K, Pawliczek P (2017) Sunshine duration and its variability in the main ridge of the Karkonosze Mountains in relation to with atmospheric circulation. *Theor Appl Climatol* 131:1173–1189

[CrossRef](https://doi.org/10.1007/s00704-017-2035-7) (https://doi.org/10.1007/s00704-017-2035-7)

[Google Scholar](http://scholar.google.com/scholar_lookup?title=Sunshine%20duration%20and%20its%20variability%20in%20the%20main%20ridge%20of%20the%20Karkonosze%20Mountains%20in%20relation%20to%20with%20atmospheric%20circulation&author=G.%20Urban&author=K.%20Migala&author=P.%20Pawliczek&journal=Theor%20Appl%20Climatol&volume=131&pages=1173-1189&publication_year=2017) (http://scholar.google.com/scholar\_lookup?

title=Sunshine%20duration%20and%20its%20variability%20in%20the%20main%20ridge%20of%20the%20Karkonosze%20Mountains%20in%20relation%20to%20with%20atmospheric%20circulation&author=G.%20Urban&author=K.%20Migala&author=P.%20Pawliczek&journal=Theor%20Appl%20Climatol&volume=131&pages=1173-1189&publication\_year=2017)

Vega LAM (1997) Diagnóstico ambiental de la provincia de Buenos Aires. Tomo II. Banco de la Provincia de Buenos Aires, Buenos Aires

[Google Scholar](https://scholar.google.com/scholar?q=Vega%20LAM%20%281997%29%20Diagn%20C3%20B3stico%20ambiental%20de%20la%20provincia%20de%20Buenos%20Aires) (https://scholar.google.com/scholar?

q=Vega%20LAM%20%281997%29%20Diagn%20C3%20B3stico%20ambiental%20de%20la%20provincia%20de%20Buenos%20Aires)

20provincia%20de%20Buenos%20Aires.%20Tomo%20II.%20Banco%20de%20la%20Pr  
ovincia%20de%20Buenos%20Aires%2C%20Buenos%20Aires)

Vera Mella N (2005) Atlas climático de irradiación solar a partir de imágenes del satélite NOAA. Aplicación a la península Ibérica. Universitat Politècnica de Catalunya, Barcelona, Doctoral Thesis. Departament de Projectes d'Enginyeria

Google Scholar ([http://scholar.google.com/scholar\\_lookup?title=Atlas%20clim%C3%A1tico%20de%20irradiaci%C3%B3n%20solar%20a%20partir%20de%20im%C3%A1genes%20del%20sat%C3%A9lite%20NOAA.%20Aplicaci%C3%B3n%20a%20la%20pen%C3%ADnsula%20Ib%C3%A9rica&author=N.%20Vera%20Mella&publication\\_year=2005](http://scholar.google.com/scholar_lookup?title=Atlas%20clim%C3%A1tico%20de%20irradiaci%C3%B3n%20solar%20a%20partir%20de%20im%C3%A1genes%20del%20sat%C3%A9lite%20NOAA.%20Aplicaci%C3%B3n%20a%20la%20pen%C3%ADnsula%20Ib%C3%A9rica&author=N.%20Vera%20Mella&publication_year=2005))

Wang L, Kisi O, Zounemat-Kermani M, Salazar GA, Zhu, Gong W (2016) Solar radiation prediction using different techniques: model evaluation and comparison. *Renew Sust Energ Rev* 61: 384–397

Google Scholar (<https://scholar.google.com/scholar?q=Wang%20L%2C%20Kisi%20O%2C%20Zounemat-Kermani%20M%2C%20Salazar%20GA%2C%20Zhu%2C%20Gong%20W%20%282016%29%20Solar%20radiation%20prediction%20using%20different%20techniques%3A%20model%20evaluation%20and%20comparison.%20Renew%20Sust%20Energ%20Rev%2061%3A%20384%E2%80%93397>)

Wang YW, Yang YH (2014) China's dimming and brightening: evidence, causes and hydrological implications. *Ann Geophys* 32:1–15. <https://doi.org/10.5194/angeo-32-41-2014> (<https://doi.org/10.5194/angeo-32-41-2014>)

CrossRef (<https://doi.org/10.5194/angeo-32-1-2014>)  
Google Scholar ([http://scholar.google.com/scholar\\_lookup?title=China%E2%80%99s%20dimming%20and%20brightening%3A%20evidence%2C%20causes%20and%20hydrological%20implications&author=YW.%20Wang&author=YH.%20Yang&journal=Ann%20Geophys&volume=32&pages=1-15&publication\\_year=2014&doi=10.5194%2Fangeo-32-41-2014](http://scholar.google.com/scholar_lookup?title=China%E2%80%99s%20dimming%20and%20brightening%3A%20evidence%2C%20causes%20and%20hydrological%20implications&author=YW.%20Wang&author=YH.%20Yang&journal=Ann%20Geophys&volume=32&pages=1-15&publication_year=2014&doi=10.5194%2Fangeo-32-41-2014))

Weber GR (1990) Spatial and temporal variation of sunshine in the Federal Republic of Germany. *Theor Appl Climatol* 41:1–9

CrossRef (<https://doi.org/10.1007/BF00866197>)  
Google Scholar ([http://scholar.google.com/scholar\\_lookup?title=Spatial%20and%20temporal%20variation%20of%20sunshine%20in%20the%20Federal%20Republic%20of%20Germany&author=GR.%20Weber&journal=Theor%20Appl%20Climatol&volume=41&pages=1-9&publication\\_year=1990](http://scholar.google.com/scholar_lookup?title=Spatial%20and%20temporal%20variation%20of%20sunshine%20in%20the%20Federal%20Republic%20of%20Germany&author=GR.%20Weber&journal=Theor%20Appl%20Climatol&volume=41&pages=1-9&publication_year=1990))

Weber GR (1994) On the seasonal variation of local relationships between temperature, temperature range, sunshine and cloudiness. *Theor Appl Climatol* 50:15–22

CrossRef (<https://doi.org/10.1007/BF00864898>)  
Google Scholar ([http://scholar.google.com/scholar\\_lookup?title=On%20the%20seasonal%20variation%20of%20local%20relationships%20between%20temperature%2C%20temperature%20range%2C%20sunshine%20and%20cloudiness&author=GR.%20Weber&journal=Theor%20Appl%20Climatol&volume=50&pages=15-22&publication\\_year=1994](http://scholar.google.com/scholar_lookup?title=On%20the%20seasonal%20variation%20of%20local%20relationships%20between%20temperature%2C%20temperature%20range%2C%20sunshine%20and%20cloudiness&author=GR.%20Weber&journal=Theor%20Appl%20Climatol&volume=50&pages=15-22&publication_year=1994))

Widén J, Carpman N, Castellucci V, Lingfors D, Olauson J, Remouit F, Bergkvist M, Grabbe M, Waters R (2015) Variability assessment and forecasting of renewables: a review for solar, wind, wave and tidal resources. *Renew Sust Energ Rev* 44:356–375

CrossRef (<https://doi.org/10.1016/j.rser.2014.12.019>)

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Variability%20assessment%20and%20forecasting%20of%20renewables%3A%20a%20review%20for%20solar%2C%20wind%2C%20wave%20and%20tidal%20resources&author=J.%20Wid%C3%A9n&author=N.%20Carpman&author=V.%20Castellucci&author=D.%20Lingfors&author=J.%20Olauson&author=F.%20Remouit&author=M.%20Bergkvist&author=M.%20Grabbe&author=R.%20Waters&journal=Renew%20Sust%20Energ%20Rev&volume=44&pages=356-375&publication\\_year=2015](http://scholar.google.com/scholar_lookup?title=Variability%20assessment%20and%20forecasting%20of%20renewables%3A%20a%20review%20for%20solar%2C%20wind%2C%20wave%20and%20tidal%20resources&author=J.%20Wid%C3%A9n&author=N.%20Carpman&author=V.%20Castellucci&author=D.%20Lingfors&author=J.%20Olauson&author=F.%20Remouit&author=M.%20Bergkvist&author=M.%20Grabbe&author=R.%20Waters&journal=Renew%20Sust%20Energ%20Rev&volume=44&pages=356-375&publication_year=2015))

World Meteorological Organization (2017) Guide to meteorological instruments and methods of observation. WMO, Geneva

**Google Scholar** ([http://scholar.google.com/scholar\\_lookup?title=Guide%20to%20meteorological%20instruments%20and%20methods%20of%20observation&publication\\_year=2017](http://scholar.google.com/scholar_lookup?title=Guide%20to%20meteorological%20instruments%20and%20methods%20of%20observation&publication_year=2017))

Xia X (2010) Spatiotemporal changes in sunshine duration and cloud amount as well as their relationship in China during 1954–2005. *Journal of Geophysical Research: Atmospheres* 115: D00K06. <https://doi.org/10.1029/2009JD012879> (<https://doi.org/10.1029/2009JD012879>)

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