HelioClim, overview

Summary

The HelioClim surface solar radiation (SSR) databases, HelioClim-1 and HelioClim-3, are based on SSR estimation from Meteosat Second Generation images. This satellite-based method used to estimate the SSR is named HelioSat-2 and was proposed and developed by the Center for Observations, Impacts and Energy of MINES ParisTech / ARMINES. The HelioClim databases are commercialized by Transvalor and are available, with other solar related web-services, at www.soda-pro.com.

Protagonists

The Center for OIE (http://www.oie.mines-paristech.fr/Accueil/) is a joint research laboratory of the French school of engineers MINES ParisTech (www.mines-paristech.eu) and ARMINES (www.armines.net). ARMINES is a "non-lucrative" association meant to be a framework for school of engineers for research activities directed to the industry.

Transvalor is a commercial company, created by ARMINES, to transfer and value into the industry the research results of the different school of engineers involved in ARMINES.

Methodology

Satellite-based methods for surface solar radiation (SSR) estimation such as the well known HelioSat method ([2], [1]) represent an operational alternative to interpolation approaches based on meteorological ground stations, as it enables a better spatial and temporal coverage.

Since 2004, the Heliosat-2 algorithm [3] applied to Meteosat Second Generation SEVIRI images has been used to update, on a daily basis, the solar resource database HelioClim-3. This database covers Europe, Africa, the Mediterranean Basin, the Atlantic Ocean and part of the Indian Ocean with a spatial resolution of approximately 5 km (see figure) and a temporal resolution up to 15 minutes. The Meteosat Second Generation data are received from Eumetsat and processed in near real time, overnight.

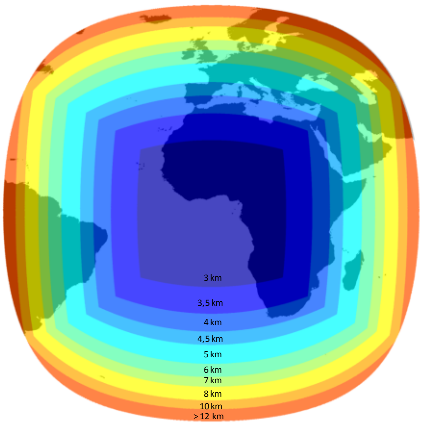

Figure: Spatial coverage and resolution of HelioClim-3 solar resource database.

There are two independent acquisition and processing chains for the HelioClim-3 database: one in MINES ParisTech, and one in Transvalor, in Sophia Antipolis. In brief, the process of these two chains begins by the merging of these two images into a synthetic image normalized according to the sensor and the sun elevation. As this image is located in the visible part of the spectra, the idea of the HelioSat-2 method is the following: the whiter the pixel, the cloudier. The method calculates the proportion of cloud contained in each MSG pixel compared to the same pixel value in clear sky conditions, in order to deduce the irradiation value at ground level.

HelioClim-3

MSG images are routinely processed with the Heliosat-2 method every 15 min to update the HC3 database [3]. Heliosat-2 combines a clear sky model with a "cloud index". The cloud index approach is based on the assumption that the appearance of a cloud over a pixel results in an increase of reflectance in visible imagery; the attenuation of the downwelling shortwave irradiance by the atmosphere over a pixel is related to the magnitude of change between the reflectance that should be observed under a cloud-free sky and that currently observed. This magnitude of change is quantified by the cloud index.

Versions 4 and 5 are the two most advanced versions of HC3. The version 4 uses the climatological European Solar Radiation Atlas clear-sky model [4], based on the Linke Turbidity Factor. The climatological database of Linke Turbidity factor has been estimated using ground measurements worldwide [5], and led to one map per month. They have been temporally interpolated to generate one map per day. The major drawback of this climatological database is that it never updated to take into account the attenuation or increase of the atmosphere turbidity due to local effects such as maritime inputs, volcanoes, fires, evolution of the water vapor content, pollution… The version 5 of HelioClim-3 [6] is an attempt to overcome this limitation, by exploiting the McClear clear sky model [7], also outcome of the MACC and CAMS projects. McClear provides updated information on the content of the atmosphere, combining both in-situ and satellite inputs.

HC3 estimates of SSI are available at integration periods (or time steps) of 15 min, 1 h, 1 day and 1 month. The temporal coverage of data is from 2004-02-01 up to current day-2 for the version 5, and day-1, real time and even d+1 forecast data for version 4. HC3 provides 15 minutes Global Horizontal Irradiation values, on which decomposition models are applied to compute all the components of the radiation over a horizontal, fix-tilted and normal plane for the actual weather conditions. When a request is launched, post-processing layers are applied for instance to modulate the radiation values inside the MSG pixels to take into account the actual elevation of the required location, or to compute the shadowing effect of the far horizon. HC3 time series can be retrieved either via the SoDa website, or automatically via a machine-to-machine access. Several other value-added services based on this resource are also available as a one-shot request, such as the purchase of a volume of HC3 time series or Typical Meteorological Years on a given area, irradiation maps, measurement completion…

Accuracy and uncertainties

Please refer to the following URL to read the uncertainty results of several validation benchmarks between HelioClim-3 version 4 and 5 with ground station measurements:

http://www.soda-pro.com/help/helioclim/helioclim-3-validation

The people in Transvalor

Dr Etienne Wey is the General Manager of Transvalor. He graduated from the engineering school INSA in Lyon and received his Ph.D at MINES ParisTech in 1984. He worked on the development of the software Forge2 then established the software department of Transvalor, in Sophia Antipolis. In collaboration with the CEP Mines ParisTech research centre, he started in 2008 a commercial activity based on the valorisation of the HelioClim databases and SoDa web-site.

Ms Dr. Claire Thomas received her PhD from MINES ParisTech in 2006 on the subject "fusion of images". She then worked as a post-doc at INRIA in Rennes on meteorology using EO data and assimilation techniques. Claire Thomas published several peer-reviewed articles in international journals. She joined Transvalor in April 2009 to work full time on the SoDa project and the HelioClim databases use and commercialisation.

Ms Dr. Mathilde Marchand received her PhD from MINES ParisTech in 2014 on ACV. She has been hired in July 2015 to help the SoDa answer all the requests from the customers.

The people in MINES ParisTech

Dr. Philippe Blanc graduated from the engineering school SupTelecom and received his PhD degree from MINES ParisTech in 1999 in the field of engineering sciences and applied mathematics. He has been working as a research engineer at Aérospatiale, then Thalès Alenia Space in signal and image processing and data fusion for Earth Observation systems and various projects where scientific support in signal and image processing, statistics, algorithmic prototyping and applied mathematics is required. He joined the CEP Mines ParisTech in 2007.

Dr. Thierry Ranchin received his PhD degree in applied mathematics in 1993 and his "Habilitation à diriger les recherches" in 2005. His current research interests are the development of innovating methods for fusion of multisources data, and mapping of geophysical parameters for renewable energies. He is the co-chair of the Energy Community of Practices of the Global Earth Observation System of Systems (GEOSS) initiative and the co-chair of the User Interface Committee within the

Group of Earth Observation (GEO). Since November 2007, he is the deputy director of the CEP MINES ParisTech.

Prof. Lucien Wald is a Professor at MINES ParisTech since 1991. He is specialised in geophysics (meteorology, oceanography, air quality), remote sensing and image processing. He received several Awards for his research in information technologies and especially in data fusion in environment. He was responsible for the creation of the databases and the maps for the European Solar Radiation Atlas. He was the scientific coordinator of the SoDa project which gave birth to the SoDa web site and the HelioClim databases.

Publications

More publications here: http://www.soda-pro.com/help/publications

[1] Beyer H. G., Costanzo C., Heinemann D., Modifications of the Heliosat procedure for irradiance estimates from satellite images. Solar Energy 56(3); 207(1996).

[2] Cano D., Monget J., Albuisson M., Guillard H., Regas N., and Wald L., A method for the determination of the global solar radiation from meteorological satellite data. Solar Energy 37; 31(1986).

[3] Rigollier C., Lefèvre M., Wald L., 2004. The method Heliosat-2 for deriving shortwave solar radiation data from satellite images. *Solar Energy*, 77(2), 159-169.

[4] Rigollier C, Bauer O, Wald L. On the clear sky model of the 4th European Solar Radiation Atlas with respect to the Heliosat method. Solar Energy 2000;68:33-48

[5] Remund J., Wald L., Lefèvre M., Ranchin T., Page J. Worldwide Linke turbidity information. Proceedings of ISES Solar World Congress, 16-19 June 2003, Göteborg, Sweden.

[6] Qu Z, Gschwind B, Lefevre M, Wald L. Improving HelioClim-3 estimates of surface solar irradiance using the McClear clear-sky model and recent advances in atmosphere composition. Atmospheric Measurements Techniques 2014;7:3927–3933

[7] Lefevre M, Oumbe A, Blanc P, Espinar B, Gschwind B, Qu Z et al.. McClear: a new model estimating downwelling solar radiation at ground level in clearsky conditions. Atmos. Measur. Tech. 2013;6:2403–2418