A SHORTWAVE RADIATION DATABASE TO SUPPORT GODAE-RELATED ACTIVITIES

Mireille LEFEVRE, Christelle RIGOLLIER, Sylvain CROS, Michel ALBUISSON and Lucien WALD

Ecole des Mines de Paris

BP 207, 06904 Sophia Antipolis, France

`lucien.wald@ensmp.fr`

Abstract – A new method Heliosat-II was designed for the conversion of spaceborne observations made in the visible range by geostationnary satellites into SW radiation available at ocean level. It offers several improvements in operation and accuracy with respect to previous methods. Typical bias for irradiance for a month is 3 W m^{-2}. A database is being produced, covering the Eastern Atlantic Ocean, Europe and Africa from 1985 onwards and for each day. This database is accessible through the SoDa service on a free basis (http://soda.jrc.it).

1 – Introduction - The method Heliosat-II

Shortwave (SW) radiation is an element of the radiation budget, an essential component in climate studies that will be supported by the GODAE experiment. The network of stations measuring radiation is very scarce in the ocean and coastal areas.[1] and [2] demonstrate that a proper processing of satellite data provides better results than interpolation techniques. Several methods are available for the conversion of spaceborne observations made in the visible range by geostationnary satellites into SW radiation available at ocean level. Our concern is the series of Meteosat satellites that observe the Eastern Atlantic Ocean and the Mediterranean Sea for several years. When operated on a routine basis, many of these methods exhibit several drawbacks, one of them being the poor accuracy in irradiance [3].

We designed a new method that is capable of processing long time-series of images acquired by the series of sensors aboard the Meteosat satellites. The method is using the same principle than several methods of proven quality: [4] [5] [6] [7] [8] [9] [10] [11]. With respect to these methods, the new one, called Heliosat-II, offers several improvements in operation and accuracy. These improvements are due to several causes:

- the Meteosat data are calibrated and converted into radiances [12];
- we use a new database of monthly values of the atmospheric optical turbidity for clear skies available on cells of 5' of arc angle in size (SoDa Web site: http://soda.jrc.it);
- we use terrain elevation TerrainBase database using the same cell size (useful for land / ocean separation);
- a better modelling of the irradiation under clear-skies and overcast skies was performed [13];
- more physical description of the optical processes was made possible by the calibration step; known proven models are implemented in the method;
- observations of [14] were used to model the spatial distribution of radiances of the very thick clouds;
- changes in ocean albedo due to sun glitter are taken into account.

2 – Results – Constructing a database

We made comparisons between satellite-derived assessments and measurements performed in the world radiation network in Europe and Africa. The results depend upon several parameters; the type of data (high-resolution or B2 format) and the number of pixels whose values are averaged for the comparison with the irradiation measurements.

As for the high-resolution data, assessments were compared to observations made by 60 stations in Europe for one year. The bias and root mean square error (RMSE) for the assessment of the irradiance for a month are equal

to respectively 2 and 11 W m^{-2} on cells of 5' of arc angle in size (approx. 10 km at mid-latitude). The RMSE may decrease down to 4 W m^{-2} if assessments are averaged over cells of 0.5° of arc angle (see Table).

The performances are worse for the data in B2 format. This format results from a sub-sampling of the high-resolution data. Briefly written, one pixel out of six original pixels is kept. Estimates at the geographical locations of the stations are therefore produced by spatial interpolation [15]. Comparisons were performed using 60 stations in Europe and 30 stations in Africa for the same year. The bias and RMSE are better than respectively 3 and 17 W m^{-2} for one month and a cell of 5'. The RMSE decreases to 9 W m^{-2} for cells of 0.5° in size.

Data in B2 format were collected from Eumetsat. They were quality-controlled and calibrated. The method Heliosat-II is being operated to produce a database of SW downward radiation for the Eastern Atlantic Ocean, Europe and Africa from 1985 onwards and for each day. This database is accessible through the SoDa service on a free basis [16]. Further, tools are available through this service to estimate longwave downward irradiance and net irradiance from the SW downward irradiance. The Heliosat-II method can be operated in real-time. When applied to Meteosat data (MOP and MSG), it produces maps of downward SW irradiance within the hour following the acquisition.

Errors (W m^{-2}) in assessing SW downward irradiance for a month

	Hi-Res images		B2 format	
	5' cell	0.5° cell	5' cell	0.5° cell
Bias	2	2	3	3
RMSE	11	4	17	9

References

[1] Perez R., Seals R., Zelenka A., 1997, Comparing satellite remote sensing and ground network measurements for the production of site/time specific irradiance data, *Solar Energy*, **60**, 89-96.

[2] Zelenka A., Perez R., Seals R., and Renné D., 1999, Effective accuracy of satellite-derived hourly irradiances, *Theoretical and Applied Climatology*, **62**, 199-207.

[3] Rigollier C., Wald L., 1999, The HelioClim Project: from satellite images to solar radiation maps. In *Proceedings of the ISES Solar World Congress 1999*, Jerusalem, Israel, July 4-9, 1999, volume I, pp 427-431.

[4] Pastre C., 1981, Développement d'une méthode de détermination du rayonnement solaire global à partir des données Meteosat, *La Météorologie*, VIe série N°24, mars 1981.

[5] Möser W., Raschke E., 1983, Mapping of global radiation and of cloudiness from Meteosat image data: theory and ground truth comparisons, *Meteorologische Rundschau*, **36**, 33-41.

[6] Möser W., Raschke E., 1984, Incident solar radiation over Europe estimated from Meteosat data, *Journal of Applied Meteorology*, **23**, 166-170.

[7] Cano D., Monget J.M., Albuisson M., Guillard H., Regas N., Wald L., 1986, A method for the determination of the global solar radiation from meteorological satellite data, *Solar Energy*, **37**, 31-39.

[8] Diabaté L., Demarcq H., Michaud-Regas N., Wald L., 1988, Estimating incident solar radiation at the surface from images of the Earth transmitted by geostationary satellites: the Heliosat Project, *International Journal of Solar Energy*, **5**, 261-278.

[9] Beyer H.G., Costanzo C., Heinemann D., 1996, Modifications of the Heliosat procedure for irradiance estimates from satellite images, *Solar Energy*, **56**, 3, 207-212.

[10] Stuhlmann R., Rieland M., Raschke E., 1990, An improvement of the IGMK model to derive total and diffuse solar radiation at the surface from satellite data, *Journal of Applied Meteorology*, **29**, 596-603.

[11] Delorme C., Gallo A., Olivieri J., 1992, Quick use of Wefax images from Meteosat to determine daily solar radiation in France, *Solar Energy*, **49** (3), 191-197.

[12] Rigollier C., Lefèvre M., Blanc Ph., Wald L., 2002. The operational calibration of images taken in the visible channel of the Meteosat-series of satellites. *To be published by Journal of Atmospheric and Oceanic Technology*.

[13] Rigollier C., Bauer O., Wald L., 1999, On the clear sky model of the 4th European Solar Radiation Atlas with respect to the Heliosat method, *Solar Energy*, 68(1), 33-48.

[14] Taylor V.R., Stowe L.L., 1984, Reflectance characteristics of uniform Earth and cloud surfaces derived from Nimbus 7 ERB, *Journal of Geophysical Research*, **89**(D4), 4987-4996.

[15] Lefèvre M., Remund J., Albuisson M., Wald L., 2002, An improved distance-based interpolation scheme. *To be published in Agricultural and Forest Meteorology*.

[16] Wald L., 2000. SoDa: a project for the integration and exploitation of networked solar radiation databases. *In Proceedings of the European Geophysical Society Meeting, XXV General Assembly* (CD-ROM).