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Data quality assessment and monthly stability of ground solar radiation in Galicia (NW Spain)

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Abstract

Routine measurements of irradiance are valuable for many research fields such as energy applications. However, ground data of solar global radiation can present questionable values. In this study, a set of check procedures was used to test the quality of solar global radiation measurements taken at 75 observatories in Galicia (NW Spain) during 2005–2007. In this short period, the number of radiometric stations in the region increased from 30 to 75. A simple reliability index was defined to characterize the ability of a given station to supply quality data during the study period. Most of the data fulfilled the control procedures; moreover, some data could be recalculated from daily and 10-min records. However, data from certain stations were removed. Then, the stability of the solar radiation was assessed through statistical analyses. Monthly global radiation followed normal distributions in 35 out of 36 months, December 2007 being the only exception. Irradiation was more stable in summer and winter months than in spring and autumn. Records from certain stations showed a high correlation. Solar radiation from two station networks taken from the dataset was interpolated in order to exemplify the improvement obtained from using a higher quality dataset when mapping this variable. The obtained database can be used in further research.

Keywords: Quality control; Solar irradiation; Galicia (Spain); Semivariogram

1. Introduction

Solar radiation is the primary energy source on our planet since it drives most water, energy, and carbon cycles in the Earth system. Solar radiation data are required in many research fields. In fact, architects, engineers and scientists involved in the field of solar energy systems require solar data measured at the vicinity of their application.

Despite of its great importance, solar radiation data, compared to other meteorological variables, are more subjected to errors, such as technical failures and operation-related problems (Moradi, 2009).

Solar radiation measurements at ground level are made primarily with pyranometers, which are hemispherically sensitive sensors and measure incoming solar radiation on a horizontal ground level during a given time (Geiger

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et al., 2002). As pointed out by Younes et al. (2005), the most common sources of errors arising from the sensors are related to their cosine, azimuth and temperature responses, their spectral sensitivity, their stability, their non-linearity, and, in the case of thermopile pyranometers, their dark offset (nocturnal) long-wave radiation error. These errors are corrected by experienced personnel; however, other errors may arise from the environment were the sensors are located (topography, vegetation and other obstacles), which are not corrected, usually. These obstacles may lead to an unfulfilling of the recommendations of the World Meteorological Organization (WMO, 2008). Although this kind of errors is neither detected nor corrected by a quality-check performed on an individual station, they can be detected by a quality-check carried out on a network of stations.

Current radiation records are often sparsed over the world compared to other meteorological variables, due to the cost, maintenance, and calibration requirements of the measuring equipment (Thornton and Running, 1999). Therefore, strict quality controls are mandatory in order to build a reliable database for further uses. As suggested by Geiger et al. (2002), the irradiation measurements should be checked in two stages: technical control, and quality control. Recent studies presented different assessments and criteria for the quality control of solar radiation measurements (Espinar et al., 2009; Geiger et al., 2002; Moradi, 2009; Tang et al., 2010; Shi et al., 2008; Younes et al., 2005). These authors reported the need to control solar radiation measurements and they also suggested several criteria to filter erroneous data. In summary, the reports from these authors have the common characteristic of considering only those values collected at the measurement station for performing the quality-check of the data. However, these premises can be complemented accounting for: (a) the values that are within the upper and lower thresholds may be erroneous as well; (b) many stations do not collect data on diffuse radiation therefore the techniques needing this variable cannot be used in these situations; and (c) in some regions the density of stations has increased and there is a high correlation between irradiation data recorded in different stations. The latter fact may be used as a factor for error detection and even for data correction, since redundant information can appear when the station network is considered instead of only those values taken at a given station.

In Spain, solar radiation data has been widely used for mapping purposes in Catalonia (Flores Tovar and Baldasano, 2001; Santabàrbara et al., 1996). However, other Spanish regions have a rather recent radiometric-measuring network. This is the case for Galicia (NW Spain), where solar radiation data was scarce with only four stations measuring this variable in 1981. Since then, only a few studies reported data on solar radiation (Naranjo and Pérez Muñuzuri, 2006; Vázquez Váquez, 2005), but the quality of their data has not been checked. Moreover, the network of stations measuring global solar radiation in this region greatly increased in the last few years (from 30 in 2005 to 75 stations in 2007).

The main objective of this paper was to evaluate the quality of the global solar radiation measurements collected in Galicia during a short time-period when the radiometric station network increased steadily. We also checked whether the radiation follows a normal Gaussian distribution at the monthly level as it is considered to do at a yearly level. Moreover, we assessed the temporal and spatial relations between measurements, which are essential to detect and correct anomalous data from a given station using data from other stations. Therefore, the quality-check performed in this study covers both scales, temporal and spatial.

To our knowledge, this is the first study that uses ground measurements of solar radiation in Galicia. The former studies estimated the global solar radiation from other related climatic attributes (Paz González and Díaz-Fierros Viqueira, 1981) or used satellite data (Vázquez Váquez, 2005). Furthermore, a quality check of solar radiation datasets in Galicia has never been done before; hence, the current work can be taken as a basis for future research. Results from the present paper can be used to map global solar radiation in order to obtain an atlas which can be used for potential solar energy applications. In fact, the final section in the results of this paper presents a comparison between the average monthly solar irradiation for 2007 obtained from two datasets comprising station networks providing measurements of different quality.

2. Materials and methods

2.1. Data and domain

Galicia is the most northwestern region of Spain, with a surface area of approximately 29,570 km^2. It is bordered by the Cantabric Sea to the north and the Atlantic Ocean to the west. Galicia is a humid and well-ventilated area frequently affected by westerly winds and frontal systems. Despite of its relatively small surface, this region shows great climate variability, both spatial, presenting 11 ombrothermical domains (Martínez Cortizas and Pérez Alberti, 1999), and temporal (Naranjo and Pérez Muñuzuri, 2006). The high humidity level on this region implies an important attenuation of solar radiation due to water vapor.

Global radiation data come from five different sources: two public institutions with climatic and meteorological purposes (MeteoGalicia and AEMet); other two public institutions with agroclimatic purposes (REVIAG and SIAR); and one enterprise devoted to supply energy (ENDESA). Monthly mean global radiation was collected from January 2005 to December 2007. The reasons for choosing this time-period were: (i) before 2005 there were only very few stations measuring global solar radiation in the region and (ii) between 2005 and 2007 the number of stations measuring this attribute increased from 30 to 75.