Evaluation of Satellite-Based, Modeled-Derived Daily Solar Radiation Data for the Continental United States

Jeffrey W. White,* Gerrit Hoogenboom, Paul W. Wilkens, Paul W. Stackhouse Jr., and James M. Hoell

ABSTRACT

Decision support tools for agriculture often require meteorological data as inputs, but data availability and quality are often problematic. Difficulties arise with daily solar radiation (SRAD) because the instruments require electronic integrators, accurate sensors are expensive, and calibration standards are seldom available. NASA’s Prediction of Worldwide Energy Resources (NASA/POWER; power.larc.nasa.gov) project estimates SRAD based on satellite observations and atmospheric parameters obtained from satellite observations and assimilation models. These data are available for a global 1° × 1° coordinate grid. The SRAD can also be generated from atmospheric attenuation of extraterrestrial radiation (Q$_{0}$). We compared daily solar radiation data from NASA/POWER (SRAD$_{NP}$) with instrument readings from 295 stations (observed values of daily solar radiation, SRAD$_{OB}$) and values estimated by Weather Generator for Solar Radiation (WGNER) generator. Two sources of air temperature and precipitation records provided inputs to WGNER: the stations reporting solar data and the NOAA Cooperative Observer Program (COOP) stations. The resulting data were identified as solar radiation values obtained using the Weather Generator for Solar Radiation software in conjunction with daily weather data from the stations providing values of observed values of daily solar radiation (SRAD$_{WG}$) and solar radiation values obtained using the Weather Generator for Solar Radiation software in conjunction with daily weather data from NOAA COOP stations (SRAD$_{CG}$), respectively. Values of SRAD$_{NP}$ for individual grid cells consistently showed higher correlations (typically 0.85–0.95) with SRAD$_{OB}$ than did SRAD$_{WG}$ or SRAD$_{CG}$. Mean values of SRAD$_{OB}$–SRAD$_{WG}$, and SRAD$_{NP}$ for a grid cell usually were within 1 MJ m$^{-2}$ d$^{-1}$ of each other, but NASA/POWER values averaged 1.1 MJ m$^{-2}$ d$^{-1}$ lower than SRAD$_{OB}$. This bias increased at lower latitudes and during summer months and is partially explained by assumptions about ambient aerosol properties. The NASA/POWER solar data are a promising resource for studies requiring realistic accounting of historic variation.

Many agricultural and natural resource management efforts involve spatial scales above the field and farm levels. Applications range from monitoring regional water use, to identifying promising zones for production of new crops, to targeting of specific cultivars or crop traits, to determining the potential impact of climate change and potential options for adaptation. Spatial assessments often consider climatic variation and increasingly, long-term records of daily weather data are required to examine climatic risks or trends related to climate change. Such analyses, however, are usually constrained by the availability and quality of the observed long-term meteorological data. Weather station data may not be available from the regions of interest, and individual stations may lack data for long time intervals. Weather data per se may show local variation due to positioning of the station and the instrument, instrument calibration drift, change in instrumentation, and other factors (Davey and Pielke, 2005; Younes et al., 2005). Solar radiation data have long been recognized as especially problematic (Durrenberger and Brazel, 1976; Stoffel et al., 2000). Radiation must be correctly integrated at low sun elevation angles and over all wavelengths. Radiometers using thermopiles are expensive, while lower-cost silicon pyranometers are less accurate. Both types of sensors require electronic circuitry to integrate readings over time and are sensitive to ambient temperatures. Sensor calibration is difficult because accurate reference values (besides 0) cannot be produced through simple techniques; thus sensors are usually cross-calibrated against radiometers whose calibrations are traceable to standards such as those maintained by the National Institute of Standards and Technology.

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