

# NASA'S SUPPORT OF INTEGRATED RENEWABLE ENERGY SYSTEMS THROUGH PROVISION OF SOLAR AND METEOROLOGICAL RESOURCE INFORMATION

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## ABSTRACT

Improvements to NASA Surface Meteorology and Solar Energy (SSE) web site are now being made through the Prediction of Worldwide Energy Resource (POWER) project under NASA Earth Science Applications Energy Management Program. The current status of SSE and POWER research towards upgrading estimates of solar and meteorological parameters from NASA satellite measurements and analysis are discussed. Part of this work involves collaborating with the National Renewable Energy Laboratory (NREL) and other partners in the renewable energy field. POWER plans including historic, near-term and forecast datasets are also overviewed.

## 1. INTRODUCTION

NASA's Science Mission Directorate has long supported satellite systems and research providing data important to the study of climate and climate processes. These data include long-term estimates of meteorological quantities and surface solar energy fluxes. Satellite based products have been shown to be accurate enough to provide reliable solar resource data over regions where surface measurements are sparse or nonexistent (1, 2). NASA supported the development of the Surface Meteorological and Solar Energy (SSE) dataset providing internet based access to parameters designed for the solar power and other renewable energy system design needs (3). Now, NASA has established Energy Management theme within the ESE Applications Program. Under this program the Prediction of Worldwide Energy Resource (POWER) project has been initialized to improve upon the SSE dataset and create datasets from new satellite systems and forecast modeling

directly applicable to the energy sector decision support systems (DSS) (4). The POWER project continues and expands upon government and industry partnerships including the Department of Energy (National Renewable Energy Laboratory) and the Natural Resources Canada (NRCan) organization of the Canadian government. This paper gives an overview of the NASA POWER activities related to the development of parameters for the solar power renewable energy industries.

First, the current status of the SSE dataset is reviewed. SSE is now being upgraded to version 6 that maintains direct links to RETScreen™ (5), SolarSizer™ (6), and HOMER design tools. Global parameters of solar energy fluxes including estimates of direct and diffuse fluxes are provided at the web site along with information regarding solar geometry, cloudiness, and clearness indexes. Significant changes to the meteorological parameters are noted and access to these parameters are given through a prototype web site. Lastly, the vision of POWER towards the development of future long-term datasets including near-term and forecasted products will be presented. These plans include the derivation of parameters from many of NASA's most recent satellite missions including the Terra and Aqua polar orbiting platforms. The plans also include development of datasets from forecasts of short to long-term weather and climate from NASA and NOAA modeling.

## 2. SSE CURRENT STATUS AND UPDATES

As of the date of this writing, Chandler et al. (7) still describes the current version of SSE available through the internet at <http://eosweb.larc.nasa.gov/sse/> and presents an assessment of data quality. However, the POWER

project is preparing SSE v6.0 which is scheduled for full release in summer 2007.

The POWER project has now processed 22 years worth of meteorological data from the NASA Global Modeling and Analysis Office Goddard Earth Observing Model (GMAO GEOS-4) (8,9) and has prepared these data for inclusion on the web site. Using these data the inputs of the solar energy parameters were upgraded with newly processed solar data from the NASA/GEWEX SRB project (10). The project has just recently completed a 22 year run spanning from July 1983 through June 2005 using the GEOS-4 reanalysis meteorology. All the cloud and solar parameters will be computed using the additional years cloud and solar flux data applying the same methodologies as described on the web site. Chandler et al. (11) gives a description of SSE v6.0 and provides validation results for the new GEOS-4 meteorological parameters.

Final evaluation of the newly processed solar irradiance parameters using the validation strategy as shown in Stackhouse et al (12) is being performed at this time and results are expected by the date of the presentation in July 2007. The longer version will also provide the opportunity to compare to 10 years of Baseline Surface Radiation Budget Data (BSRN). Validation will also be performed for daily and monthly averages predating BSRN using the Global Energy Balance Archive (GEBA) and the World Radiation Data Centre (WRDC) data sets. Comparisons against various regions of the world, cloudy/clear-skies, and time series analysis are being performed.

### 3. NASA POWER VISION AND PLANS

Besides upgrading the SSE dataset, the long-term vision of POWER is to support the solar resource assessment research by providing improved long-term databases, faster updates to those databases from new NASA observations and analysis and the development of the solar resource forecasts from NASA and NOAA models. This supports the integrated systems approach central to all the national applications of the Earth Science Applications program. This approach is to move scientific knowledge and methodology directly to decision makers through partnering with governmental and other entities in matters of national interest. POWER supports decision makers in the energy sector in which the solar power renewable technologies reside. For instance, in addition to upgrading the SSE web site database, POWER is directly supporting collaboration between the National Renewable Energy Laboratory (NREL) under the current Memorandum of Understanding between NASA and NREL.

#### 3.1 Historic Datasets

POWER will be collaborating with NASA/GEWEX SRB to produce the first 22 year record data quantities tailored to the solar and other renewable energy information systems. This longer data set will play an increased role in the NREL effort to upgrade the National Solar Radiation Database (NSRDB) (see Wilcox et al. (13), and Perez et al (14) this conference). Solar irradiance values from this time period will be validated against more reliable surface observations during this period.

POWER is actively improving and developing historic solar resource data from the last 25 years. NASA supported projects such as ISCCP (International Satellite Cloud Climatology Project) and SRB are collaborating with NASA and non-NASA investigators to improve the historic representation of cloud and aerosol properties. Aerosols are being improved through scientific collaboration with the GOCART models (Georgia Tech/Goddard Ozone, Chemistry, Aerosol and Radiation Transport model (15).

Also, NASA GMAO is now working towards the processing of a 25+ year analysis called GEOS-5. This product will feature a doubled horizontal resolution of 0.5 x 0.0667 degree grid. Additionally, ISCCP is planning to reprocess improving long-term calibration and horizontal resolution. With the improved GOES-5 and ISCCP input data sets, SSE resolution may be increased 0.5 x 0.5 degrees in about a 1-2 year time frame.

Lastly, overlap of this dataset with the improved cloud, aerosol and radiation datasets being developed from the NASA Terra and Aqua systems will lead ultimately to a reduction in the uncertainty of solar irradiance values since these instruments are calibrated to accuracies far exceeding conventional weather observing platforms. After isolation of errors in the methodology and inputs a reprocessing of all the solar irradiance values using satellite systems for the last 20-25 years is planned.

#### 3.2 New More Focused Prototypes

The POWER project has also released two new prototypes more specifically designed to meet the needs of sustainable building engineers and architects as well as agricultural applications. These prototypes can be found at the web site:

<http://earth-www.larc.nasa.gov/solar/power>

This is an active site with regularly updated data products for evaluation of the community.

Whitlock et al (16) provides information regarding some of the new clear-sky products and their data quality to address needs in building design. Some of the 22 year solar energy and meteorological data that will eventually be released in

SSE Release 6 are found at this page. Included is the daily averaged time series from the entire period. A specific example of output is the psychrometric chart (see Figure 1) generated from combinations of the meteorological data and plotted on the fly the user's specified location.

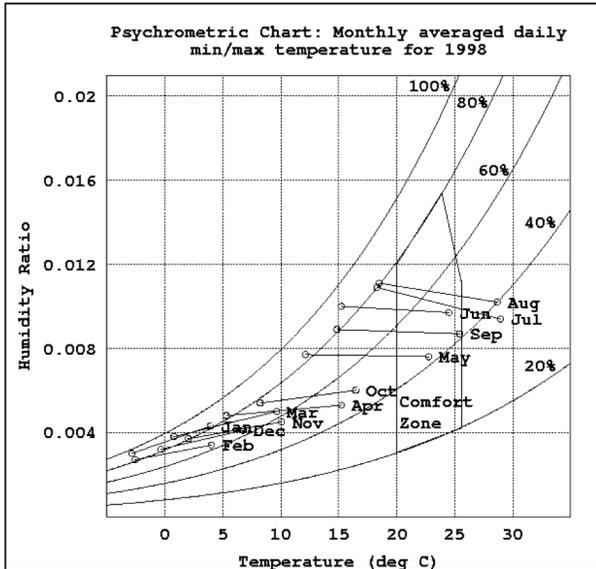


Figure 1: An example of psychrometric chart generated on the fly at the buildings prototype web site.

### 3.3 Near-Term Records

POWER is also collaborating with a team of investigators for a project called FLASHFlux (Fast Longwave and Shortwave Radiative Fluxes from CERES and MODIS) to develop global gridded solar irradiance estimates within one week of observation from NASA satellite platforms Terra and Aqua (17). The system is now operationally producing orbital data and a beta version gridded data products. An example of the output from FLASHFlux is given in Figure 2. Here the fluxes for the grid box containing the NOAA SurfRAD measurement site at Goodwin Creek, Mississippi in July and August 2007. FLASHFlux data sets contain the gridded irradiance and all relevant meteorological parameters within one week of observation. The processing system will eventually be modified to use geosynchronous data with the advantage of increased temporal resolution and transfer of cross-calibration of the NASA instruments to geosynchronous platforms. These datasets termed “Near-

term” are important for a variety of applications where the recent past is relevant for maintenance and statistical forecasting methods. Currently, access to the FLASHFlux data through the POWER project is available through the agroclimatological prototype also given at the web site noted above.

### 3.4 Forecasting Activities

The POWER project is now collaborating with the University of Albany/State University of New York to evaluate short-term forecasts of solar irradiance. Perez et al (18) give results for this work evaluating the cloud fraction forecasts for NOAA’s National Forecast Digital Database. This year the work is continuing with the addition of up to two NASA forecasting groups that assimilation satellite observations.

A new initiative has been started with the NASA’s Energy Management program to evaluate climate scenarios for impact of these scenarios to the traditional and renewable energy sectors. The climate modeling is being performed at NASA Goddard Institute of Space Studies in New York City/Columbia University. The POWER project will work with the GISS team to begin to assess solar resource in future climate scenarios compared to today’s resource.

## 4. CONCLUSIONS

This paper briefly reviewed the status of the current Surface Meteorology and Solar Energy web site database as now being improved under the POWER project of the NASA’s Earth Science Application Energy Management Program. POWER is improving historic datasets by adapting improved satellite measurements and analysis from NASA satellite missions, meteorological analysis and aerosol transport modeling to produce more reliable direct and diffuse solar fluxes. POWER is working towards developing datasets and methodologies of producing solar resource estimates within a week of the actual satellite measurement. Lastly, POWER is beginning partnerships to evaluate methods of estimating solar resource from atmospheric model output from short-term to climate time scales. All this work is being performed through partnerships in government and industry with the purpose of improving decision support systems and design tools needed to optimize solar power systems.

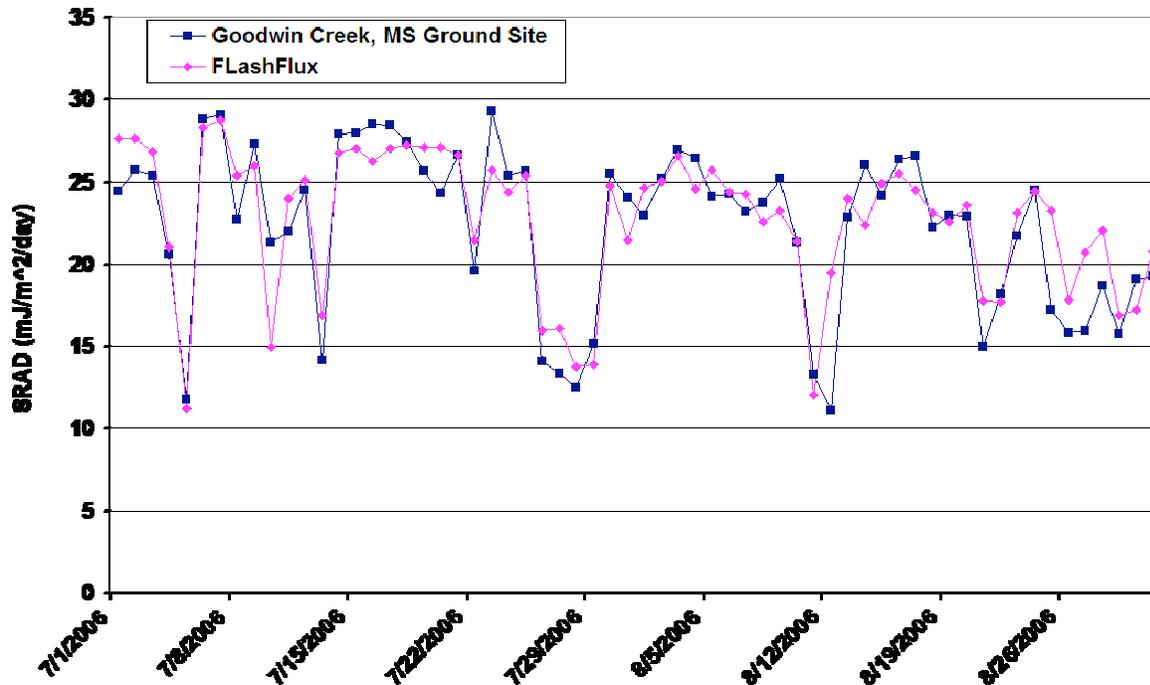


Figure 2: Estimates of the daily averaged solar irradiance at the Goodwin Creek, SurfRAD site compared against estimates from the FLASHFlux project for the dates indicated on the x-axis. The FLASHFlux data are derived from morning and afternoon polar orbiting satellites using advanced imagers and broadband radiation instrumentation. The irradiance plus all relevant meteorological information are available within 1 week of observation.

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