NEAR REAL-TIME GLOBAL RADIATION AND METEOROLOGY WEB SERVICES AVAILABLE FROM NASA

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ABSTRACT

NASA is supporting solar energy, energy-efficient building, and agriculture industries by developing contiguous environmental data sets spanning the time period from the early 1980's to near real-time via the Prediction of Worldwide Energy Resource (POWER) project. Through the POWER project, insolation on a horizontal surface (incoming solar radiation) produced at NASA Langley Research Center under the GEWEX (Global Energy and Water Cycle Experiment) Surface Radiation Budget (SRB) project and the CERES (Clouds and Earth Radiant Energy System) Fast Longwave and Shortwave Radiative Fluxes (FLASHFlux) project, along with meteorological data from NASA's Global Modeling and Assimilation Office (GMAO), are provided via a user friendly web-based data portal (http://power.larc.nasa.gov). The FLASHFlux project produces insolation on a global scale within one week of satellite observations through the use of fast radiation transfer models and reanalysis meteorological data. The meteorological data are adapted from the GMAO Goddard Earth Observing System Version 5 (GEOS-5) Data Assimilation System, and are typically available on the POWER web portal within 2 – 3 days of real time. Additionally, the meteorological data preceding the FLASHFlux era is adapted from the GEOS-4.03 version of this data set and is available via the web portal.

The purpose of this paper is to describe how POWER climatological data sets are being extended to near real-time.

1. INTRODUCTION

NASA has long supported satellite systems and research providing data, such as long-term estimates of meteorological quantities and surface solar energy fluxes, for the study of climate and climate processes. In the late 1990's, the Surface Meteorological and Solar Energy (SSE - http://eosweb.larc.nasa.gov/sse) [1] project was initiated through NASA's Applications program to provide internet-based access to parameters specifically tailored to assist in the design of solar and wind powered renewable energy systems. The goal of the SSE project was to make NASA's satellite data more readily accessible to the renewable energy community where such data was demonstrated to enhance the output of existing Discussion Support Systems. The parameters currently available through the SSE web based data archive are based primarily upon solar radiation derived from satellite observations and meteorological data from the NASA's Global Modeling and Assimilation Office (GMAO) Goddard Earth Observing System (GEOS) assimilation models, and were defined through close collaboration with industry and government partners in the solar and wind renewable energy community.

The success of the SSE project fostered the initiation of the Prediction of Worldwide Energy Resource (POWER – http://power.larc.nasa.gov) project in 2003 to improve upon the SSE data set and to create new data sets from new satellite systems and forecast modeling data. The POWER project now encompasses the SSE project data as well as data focused on the architectural and agricultural industries.

Currently, SSE Release 6 has climatological averages for the time period of July 1983 through June 2005. The next release will extend the end date of the data set. The spatial resolution is 1 x 1 degrees of latitude and longitude. Monthly average by year and daily averages of many of the parameters have been processed for the 22-year time period. Through the POWER portal, a wide range of solar and

meteorological parameters of interest to solar, building, and agricultural industries can be downloaded in tabular and/or plot format. Table 1 is a partial listing of the available parameters, of which there are over 200.

TABLE 1: A PARTIAL LISTING OF POWER/SSE PARAMETERS.

Average insolation
Midday insolation
Clear sky insolation
Clear sky days
Diffuse radiation
Direct normal radiation
Insolation at 3-hourly intervals
Insolation clearness index
Solar Geometry
Radiation on equator-pointed tilted surfaces
Daylight cloud amount
Air Temperature
Daily Temperature Range
Cooling Degree Days above 18° C
Heating Degree Days below 18° C
Earth Skin Temperature
Frost Days
Dew/Frost Point Temperature
Wind speed at 50 m
Wind Direction at 50 m
Relative Humidity
Atmospheric Pressure
Precipitation

An example of the global distribution of 22-year averaged annual insolation is shown in figure 1.

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. Insolation and many other environmental parameters (e.g. cloud amount, air pressure, average/minimum/maximum air temperature, relative humidity, dew point temperature, earth skin temperature, wind speed) of interest to the above-mentioned industries are made available on a worldwide basis through the POWER data portal.

2. NEAR REAL-TIME

Within the POWER project, the temporal span of radiation and meteorological parameters is being extended beyond the 22-year period to near real-time. These data are generated on a daily basis from the CERES FLASHFlux [2] and GEOS-5 [3] data sets that usually lag in availability by less than seven and four days, respectively. More than 27 years of data are currently available. Year-by-year daily, monthly and annual averages of many parameters, which may provide details of interannual variability, are obtainable. Figure 2 shows an example of a time series plot of daily averaged insolation at a given location for one year, 2009. User's may choose start and end dates to produce time series plots and data tables that conform to their needs.

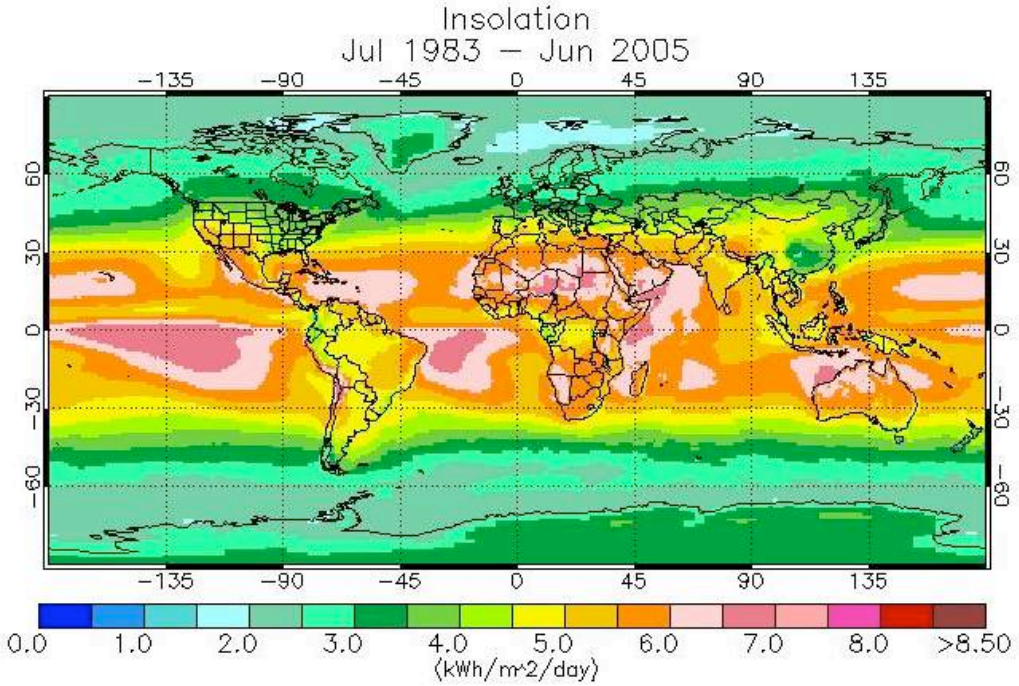

Fig 1: Annual average insolation over 22 years

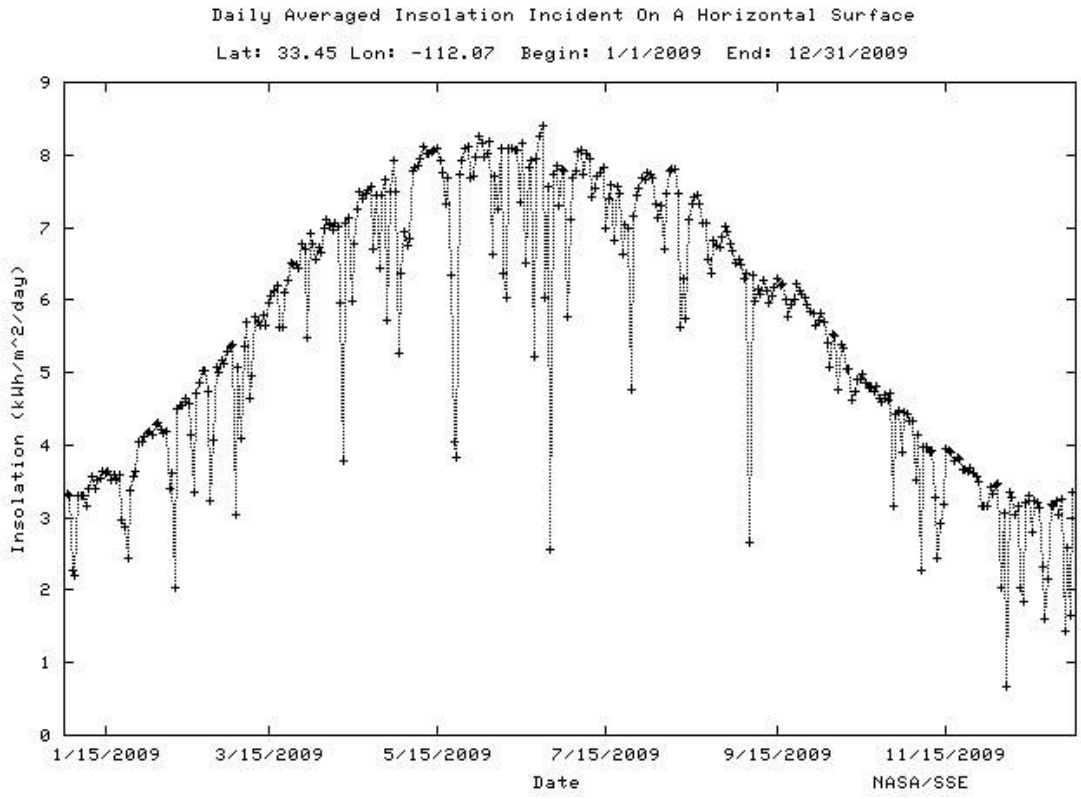

Fig 2: Time series of insolation at a given location

POWER has added several different web interfaces to present radiation and meteorological data that are appropriate for sustainable building and agroclimatology. Architects and building design engineers may choose to download psychrometric charts, climate zone maps, and daily averaged data tables with parameters, for example, shown in figure 3. Also, appropriate data (daily-integrated surface solar radiation, daily averaged dew point temperature, daily maximum and minimum temperatures, and daily precipitation) may be downloaded in the International Consortium for Agricultural Systems Applications (ICASA) format or in basic data tables for agricultural research. This data may be useful in understanding regional climatic variation and assist in agricultural crop selection, crop growth and crop yield predictions [4 and 5].

These new web interfaces follow the philosophy of the POWER team to present data sets in formats useful to the end-user. Historical through near real-time daily averaged data are available over the entire globe.

NASA/POWER Sustainable Buildings Daily Averaged Data (Evaluation Version)
Dates (month/day/year): 01/01/2010 through 01/31/2010
Location: Latitude 33.45 Longitude -112.07
Elevation (meters): Average for one degree lat/lon region = 458 Site = na
Climate zone: 3 (reference Briggs et al, http://www.energycodes.gov)
Parameter(s):
swv_dwn Average Insolation Incident On A Horizontal Surface (kWh/m^2/day)
lwv_dwn Average Downward Longwave Radiative Flux (kWh/m^2/day)
toa_dwn Average Top-of-atmosphere Insolation (kWh/m^2/day)
clr_sky Average Clear Sky Insolation Incident On A Horizontal Surface (kWh/m^2/day)
PS Average Atmospheric Pressure (kPa)
T2M Average Air Temperature At 2 m Above The Surface Of The Earth (degrees C)
T2MN Minimum Air Temperature At 2 m Above The Surface Of The Earth (degrees C)
T2MX Maximum Air Temperature At 2 m Above The Surface Of The Earth (degrees C)
RH2M Relative Humidity At 2 m (%)
DFP2M Dew/Frost Point Temperature At 2 m (degrees C)
TSKIN Average Earth Skin Temperature (degrees C)
WS10M Wind Speed At 10 m Above The Surface Of The Earth (m/s)

YEAR	MO	DY	swv_dwn	lwv_dwn	toa_dwn	clr_sky	PS	T2M	T2MN	T2MX	RH2M	DFP2M	TSKIN	WS10M
2010	01	01	3.16	6.64	4.93	3.31	97.31	10.33	2.77	19.85	31.27	-6.09	8.42	3.57
2010	01	02	3.24	6.79	4.98	3.30	96.92	13.37	7.20	22.31	32.25	-3.02	10.42	2.05
2010	01	03	3.26	6.38	4.92	3.34	97.01	11.86	4.79	21.45	35.90	-2.90	9.66	3.69
2010	01	04	3.21	6.41	4.93	-	96.99	12.32	5.50	21.40	30.58	-4.65	9.60	3.43
2010	01	05	3.36	6.21	4.96	3.39	96.92	12.62	5.65	22.02	34.00	-2.97	9.64	2.52
2010	01	06	3.15	6.68	5.12	3.36	96.83	12.31	7.04	20.44	27.09	-6.24	9.28	0.94
2010	01	07	3.05	7.07	5.06	-	96.73	13.06	9.00	20.28	32.47	-3.20	10.80	1.30
2010	01	08	3.03	7.06	5.03	3.36	97.07	12.45	5.94	20.57	33.45	-3.34	11.64	4.06
2010	01	09	3.18	7.06	5.07	3.39	97.07	13.40	10.95	16.88	25.72	-5.96	9.42	0.46
2010	01	10	2.39	7.18	5.17	-	97.11	12.38	6.79	20.53	23.06	-8.22	10.58	2.90
2010	01	11	3.44	6.38	5.25	3.46	97.19	12.62	6.45	21.46	22.78	-8.18	10.26	2.98
2010	01	12	3.45	6.80	5.11	3.52	97.15	13.52	5.43	23.18	23.34	-7.11	11.71	3.01
2010	01	13	2.85	7.47	5.31	3.47	96.65	14.93	10.86	22.59	29.86	-2.69	13.51	2.87
2010	01	14	3.46	6.76	5.32	3.49	96.63	13.06	7.37	20.05	43.14	0.74	12.44	4.49
2010	01	15	3.54	6.99	5.31	3.59	97.08	14.04	6.53	23.45	34.45	-1.54	12.33	2.88
2010	01	16	2.20	7.53	5.30	-	96.64	13.60	10.12	20.07	29.69	-3.92	10.19	1.64
2010	01	17	3.02	7.34	5.41	-	96.45	13.11	7.19	20.90	29.49	-4.44	10.42	1.51
2010	01	18	1.27	8.14	5.42	-	96.41	11.95	8.36	16.96	51.99	2.40	10.14	2.97
2010	01	19	2.71	7.94	5.52	-	96.02	12.43	8.46	17.77	77.77	8.69	12.47	5.28
2010	01	20	3.63	7.01	5.49	3.68	95.78	11.44	6.17	18.09	58.77	3.70	11.18	4.14
2010	01	21	0.74	8.53	5.52	-	94.88	13.04	10.45	15.56	85.58	10.68	12.99	10.43
2010	01	22	2.80	7.46	5.52	-	95.38	9.15	7.46	11.83	76.82	5.33	9.06	5.31
2010	01	23	3.29	6.43	5.57	3.77	96.38	7.11	3.16	13.38	62.96	0.58	6.81	3.43
2010	01	24	3.79	6.05	5.64	3.81	97.09	8.24	2.95	15.78	48.51	-2.02	6.54	2.24
2010	01	25	3.74	6.60	5.71	3.80	96.75	9.07	3.04	16.94	40.71	-3.69	7.36	1.78
2010	01	26	3.76	7.04	5.66	3.81	96.45	11.69	6.13	19.03	39.08	-1.90	10.79	1.45
2010	01	27	2.06	7.91	5.74	-	96.25	12.62	8.97	19.00	42.60	0.16	11.27	1.38
2010	01	28	3.59	7.29	5.84	-	96.48	11.98	7.14	19.22	50.57	2.03	11.07	1.40
2010	01	29	3.81	6.97	5.92	3.89	96.75	12.10	6.01	19.82	52.07	2.56	11.22	1.36
2010	01	30	3.67	6.97	5.85	-	96.49	12.82	8.17	20.45	49.30	2.44	11.36	2.82
2010	01	31	3.92	6.66	5.87	3.98	96.40	13.15	7.24	21.03	46.27	1.82	11.19	1.76

Fig 3: Sample daily averaged data table – one location – one month

3. DECISION SUPPORT TOOLS

The approach of the POWER project is to provide relevant data sets derived from NASA satellite observations and Earth system modeling to decision support tools (DST) supporting renewable energy resource management and improvements in energy efficiency. End-users require historical, near-real time, and forecasted environmental observations as inputs to their DSTs. NASA works with its partners to ensure that these specialized data sets are in consistent units and formatted to meet the needs of the partner's DST.

A long-standing partner is Natural Resources Canada, which developed the RETScreen® International Clean Energy Project Analysis Software (http://www.retscreen.net) that uses the SSE data as an input source. SSE climate data provides a useful alternative when ground-based data, or detailed resource maps, are not available for a RETScreen® project location.

POWER also supports the Hybrid Optimization Model for Electric Renewables (HOMER) DST. HOMER is a computer model that simplifies the task of evaluating design

options for both off-grid and grid-connected power systems for remote, stand-alone and distributed generation applications (http://www.homerenergy.com). HOMER is used extensively around the world for determining the optimal mix of power technologies for meeting specified load conditions at specified locations.

The POWER project is collaborating with a Pacific Northwest Regional Laboratory to support long-term parameters required for energy market forecasts. Initialization with POWER climatic data, followed by near real-time data products, is being used in load forecast models [6].

4. FUTURE

The POWER near real-time data products will continue to be extended on a daily basis using the CERES FLASHFlux data stream. POWER will update radiation parameters as new versions of SRB radiation data products covering longer time periods become available. The SRB project will continue to provide 1 x 1 degree gridded radiation data and is planning to develop higher resolution (½ x ½ degree) data sets from the anticipated reprocessing of it's chief input, which is data from the International Satellite Cloud Climatology Project (ISCCP). ISCCP processes and inter-calibrates data from the world's major geosynchronous and NOAA polar orbiting satellites. Data will become available at higher resolution from 1983 forward. And finally, a new NASA/NREL/NOAA/State University of New York project plans to use the new ISCCP product for the production of a global land 10 km x 10 km data set for the NREL National Solar Radiation Data Base (NSRDB) and the Typical Meteorological Years data sets (which are derived from the NSRDB).

Meteorological data available from the GMAO are currently being produced at the higher resolution and will also be incorporated into the POWER data sets.

5. REFERENCES

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