

NASA Surface meteorology and Solar Energy Data Sets for Commercial Applications

Introduction

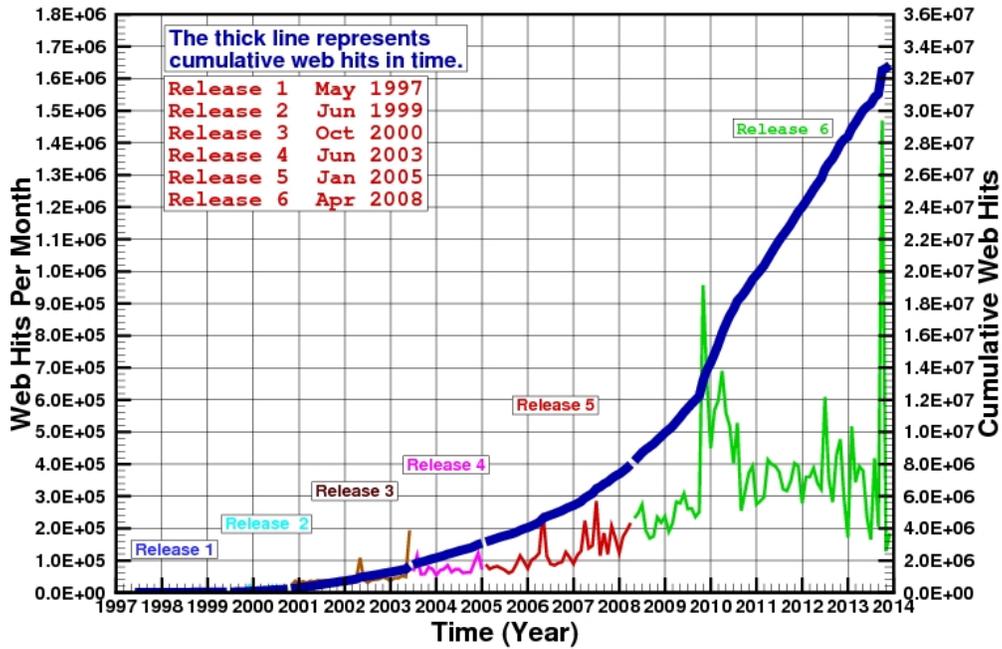
Renewable energy technologies are changing the face of the world's energy market. These technologies range in complexity from the introduction of solar ovens and simple photovoltaics panels into rural communities - to the construction of commercial buildings with integrated photovoltaics and large thermal and wind generating power plants. Crucial to the success of the emerging renewable market is the availability of accurate, global solar radiation and meteorology data. The Surface meteorology and Solar Energy (SSE) project is developing the commercial potential of NASA's cloud, radiation, and meteorology data by working closely with partners from government, commercial industry, educational, and non-profit organizations. The SSE data set, which is accelerating the realization of economic and societal benefits from NASA earth science data, is available via the Internet (<http://eosweb.larc.nasa.gov/sse/>). Currently useful in a number of applications, future versions of these data have the potential to significantly advance the global adoption of renewable energy technologies.

Estimated uncertainties of most parameters are given in the Accuracy section. Details concerning calculation methods can be found in the Methodology section. The Introduction to the Methodology section is on the web site and the entire document can be downloaded in PDF format.

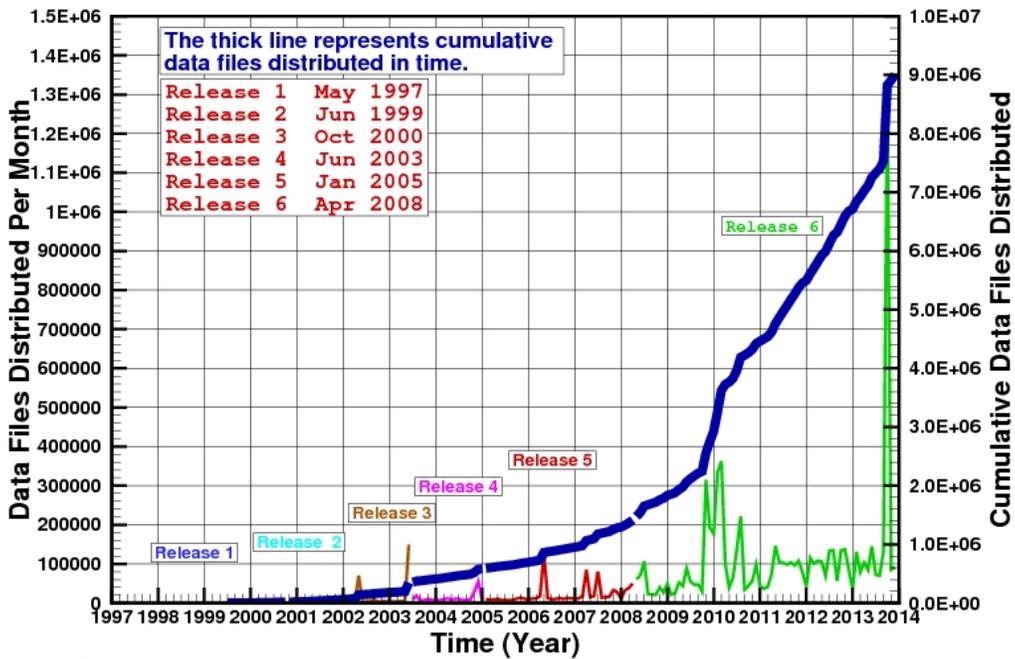
Web Site Usage and Performance

Since June 1999, the **SSE web site** (Releases 2 through 6) has generated approximately **33,171,838 hits**. Approximately **9,120,260 data documents have been downloaded by registered data users**. Users include the U.S. Air Force, U.S. State Department Headquarters, U.S. Department of Energy, USDA Forest Service, USGS Headquarters, U.S. Centers for Disease Control, U.S. Army , U.S Navy, EPA Headquarters, National Science Foundation, NOAA, The World Bank, UNESCO , International Finance Corporation, Winrock International, BP Solar, Shell Renewables, Duke Solar Energy, and over 100 U.S. Universities.

The SSE data set has been incorporated into Solar Energy International's On Line PV Design Course and it has been used by Sun Frost to size solar-powered vaccine refrigerator systems for the World Health Organization. The United Nations Environmental Program (UNEP) and Natural Resources Canada (NRCAN) are using SSE data with their greenhouse gas emission's mitigation model to allow calculation of emissions avoided by use of various types of renewable energy power systems over the globe. A CD-ROM consisting of a subset of SSE data and the RETScreen[®] International software has been developed by NRCAN and provided to the UNEP for users in underdeveloped countries that do not have good access to the Internet.



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Release Notes

Release 1, 2 and 3 -

The Release 1 web site was scientific in nature. Collaboration with users from the solar energy industry helped to make Release 2 user friendly and understandable to the general renewable energy community. The November 1999 peak in web site usage corresponds to a Natural Resources Canada (NRCan) announcement of the availability of the NASA data for use with their renewable energy software tool RETScreen® International. The software was designed to evaluate the annual energy production, costs, and financial viability of renewable energy technologies. RETScreen® International is becoming an international standard for designers, government agencies, and lending institutions. Canadian supplied ground site data or NASA SSE data are used as inputs. Release 3 became available in October, 2000 and had improved accuracy, higher resolution, and contained additional engineering parameters for the wind, ground-source heat pump, and biomass heating renewable energy technologies. Users defined their own format for both parameter worksheets and color plots.

Release 4 -

New solar radiation parameters are diffuse, direct normal, and equator-facing tilted surface radiation calculated from the 10-yr average, minimum, and maximum horizontal surface insolation. Values are given at six different equator-facing tilt angles (latitude, latitude + 15°, latitude - 15°, 0°, 90°, and optimum angle for maximum radiation).

Wind speed estimates have been improved from values in Release 3, but are still based on height above the ground, snow, water, or ice instead of the effective surface. SSE values will be lower than values based on the effective surface near the tops of vegetation. They are averages over the near-flat, 1°x 1° region with averaged vegetation roughness. Both 50- and 10-meter height values are given. Ten-meter values are for airport-type surfaces only within the average region in the standard data. Ten-meter values for other types of vegetation can be selected as part of the wind parameter listing. Speeds (average, maximum, minimum, diurnal variation, and frequency) and directions (average and diurnal variation) are provided. Wind estimates do not account for localized effects such as topography changes relative to the average height above sea level of the region. They do not account for short-term effects such as storms. Within-region local topography and land-water boundary effects must be accounted for by organizations experienced in those types of analysis. SSE winds are most useful to the hydrology, agriculture, and buildings/architectural communities at the present 1°x 1° spatial resolution. The data may be of use at some renewable energy sites for preliminary design purposes.

Heating degree day values relative to 0 and 10° C are now provided in addition to values relative to 18° C.

Three new applications allow users to view the SSE data in different ways.

- Selected parameters can be downloaded for the entire globe. Monthly and annual averages are provided in 13 columns. The data is easy to import into spreadsheet software.
- Subsetting of data tables for user defined regions can be done both spatially and temporally.
- Daily data for each 1°x 1° region provides time series data for any time period from one day to ten years.

Release 5 -

Seventy-two solar radiation and cloud parameters were replaced with true 1 x 1 degree data. SSE Release 4 was on a 1 x 1 degree grid interpolated from 2.5 x 2.5 degree data.

SSE Release 5 horizontal surface insolation values are calculated using version 2.1 of the Pinker and Laszlo algorithm (see SSE Methodology for original algorithm, Ref. [3]) as processed under the NASA/Global Energy and Water Cycle Experiment (GEWEX) Surface Radiation Budget (SRB) project. The International Satellite Cloud Climatology Program (ISCCP) DX data are used as input into the algorithm and to derive the cloud information including cloud diurnal cycle.

Additional parameters available to the user and calculated on the fly via the SSE web interface also inherit these improvements.

A new wind parameter, the Monthly Averaged Wind Speed Adjusted For Height And Vegetation Type, can be calculated for 17 different surface vegetation types and for any height from 10 to 300 meters. The vegetation type and height are specified by the user. The Gipe Power Law is used to calculate a new wind speed from the wind speed at 50 meters above the surface that is computed from output of the Goddard Earth Observing System (GEOS) version 1 analysis. Validation of surface winds using this approach at airports and other surfaces is provided in the SSE Accuracy and Methodology sections. Global/regional plots for wind speed at 100 and 150 meters are also available.

Another new parameter is monthly averaged precipitation from the Global Precipitation Climatology Project (GPCP) Version 2 Combined Precipitation Data Set.

Release 5 includes an interface between the SSE data set and the Hybrid Optimization Model for Electric Renewables (HOMER). HOMER software is a Department of Energy National Renewable Energy Laboratory product used by industry to design renewable energy systems around the globe. HOMER seamlessly ingests SSE solar radiation data without a web browser. SSE/HOMER data tables are also presented on the SSE web site.

Release 6 -

The temporal span of the SSE data set has been extended from a 10-year period to more than 22 years. The earliest available solar radiation data is for July 1983 and climatological monthly averages have been calculated for the 22-year period beginning in July 1983 and ending in June 2005. The SSE web site offers the SSE data in user friendly formats ranging from daily, monthly, and annual averages for any globally distributed 1-degree region.

Higher spatial resolution data has been made available from the NASA Goddard Earth Observing System Version 4 reanalysis model (GEOS-4) and the NASA Global Energy and Water Cycle Experiment (GEWEX) Surface Radiation Budget (SRB) project. The GEOS-4 data sets assimilates various in situ and satellite measurements to produce meteorological parameters at the horizontal resolution of $1.0^{\circ} \times 1.25^{\circ}$. The SSE project employed a bilinear interpolation scheme to provide these data products on a uniform grid of $1^{\circ} \times 1^{\circ}$. The GEWEX SRB uses the GEOS-4 temperature and humidity parameters along with satellite cloud information to produce the solar radiation values. All of the parameters are made available through the SSE web site at the $1^{\circ} \times 1^{\circ}$ spatial resolution.

A new web application provides data tables of interannual variability for every one-degree region over the globe. Using this application, any time period from 1983 through 2005 may be chosen. Multi-year averages are calculated for the selected time period, whether the selection is a few years or all 23 available years. Minimum and maximum values are calculated from the difference between the multi-year average and the lowest [highest] value for any single year in the series.

Industry Contributors

The following organizations have made significant technical contributions to the success of the SSE project:

- **BP Solar International** - Provided information on present industrywide methods used to estimate diffuse and direct normal radiation.
- **GPCo** - Provided independent assessment of wind data.
- **National Renewable Energy Laboratory (NREL)** - Provided the WRDC ground site insolation data that are incorporated into the SSE web site as part of an Interagency Agreement.

- **Natural Resources Canada (NRCan) CANMET Energy Technology Centre (CETC) - Varennes** - Provided temperature, wind, humidity, and insolation data from 1000+ sites to verify SSE data.
- **Numerical Logics, Inc.** - Provided independent assessment of accuracy results.
- **Solar Energy International (SEI) - Center for Renewable Energy and Sustainable Technology (CREST)**. Both companies advised on the renewable energy industry, and develop applications of the data.
- **Solar Household Energy, Inc.** - Advised on SSE web site development.
- **The State University of New York at Albany, Atmospheric Sciences Research Center** - Provided models for diffuse and direct normal radiation calculations.