



ESIP Summer Meeting, July 2010, Knoxville, TN

Using NASA Satellite and Model Analysis for Renewable Energy and Energy Efficiency Applications

Paul Stackhouse (NASA LaRC)

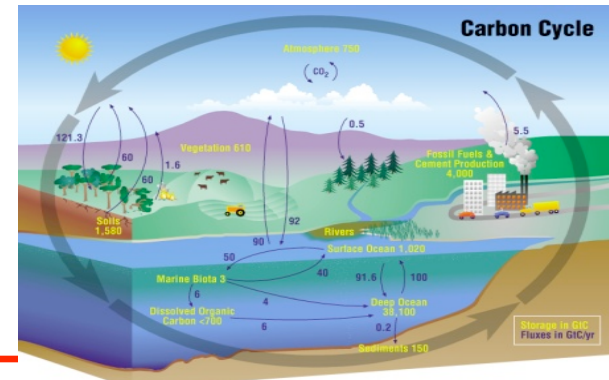
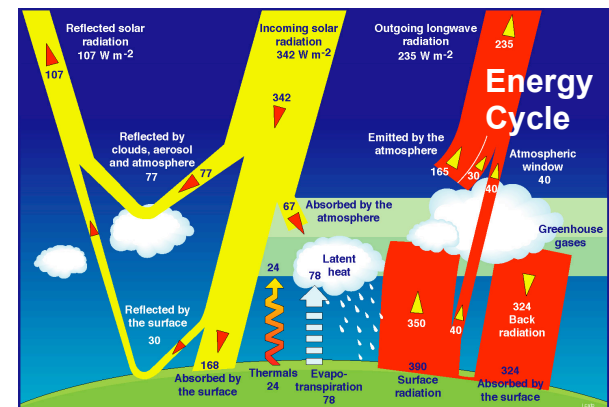
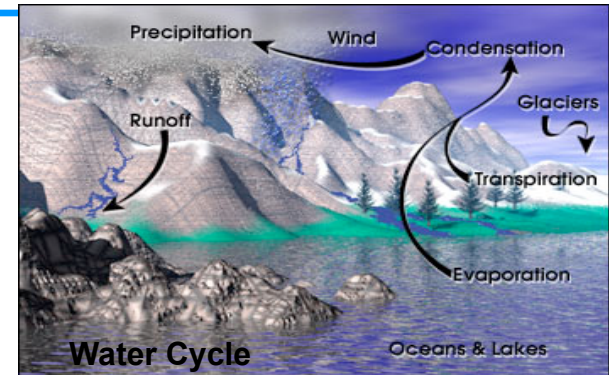
***Charles H. Whitlock, James. M. Hoell, David Westberg and
Taiping Zhang (SSAI),***

***and grateful acknowledgement to NASA Partners at GISS,
GMAO, LaRC ASDC, Partners at DOE NREL, NRCan
RETScreen, State University of New York - Albany and
numerous small companies***



Researching Science Questions

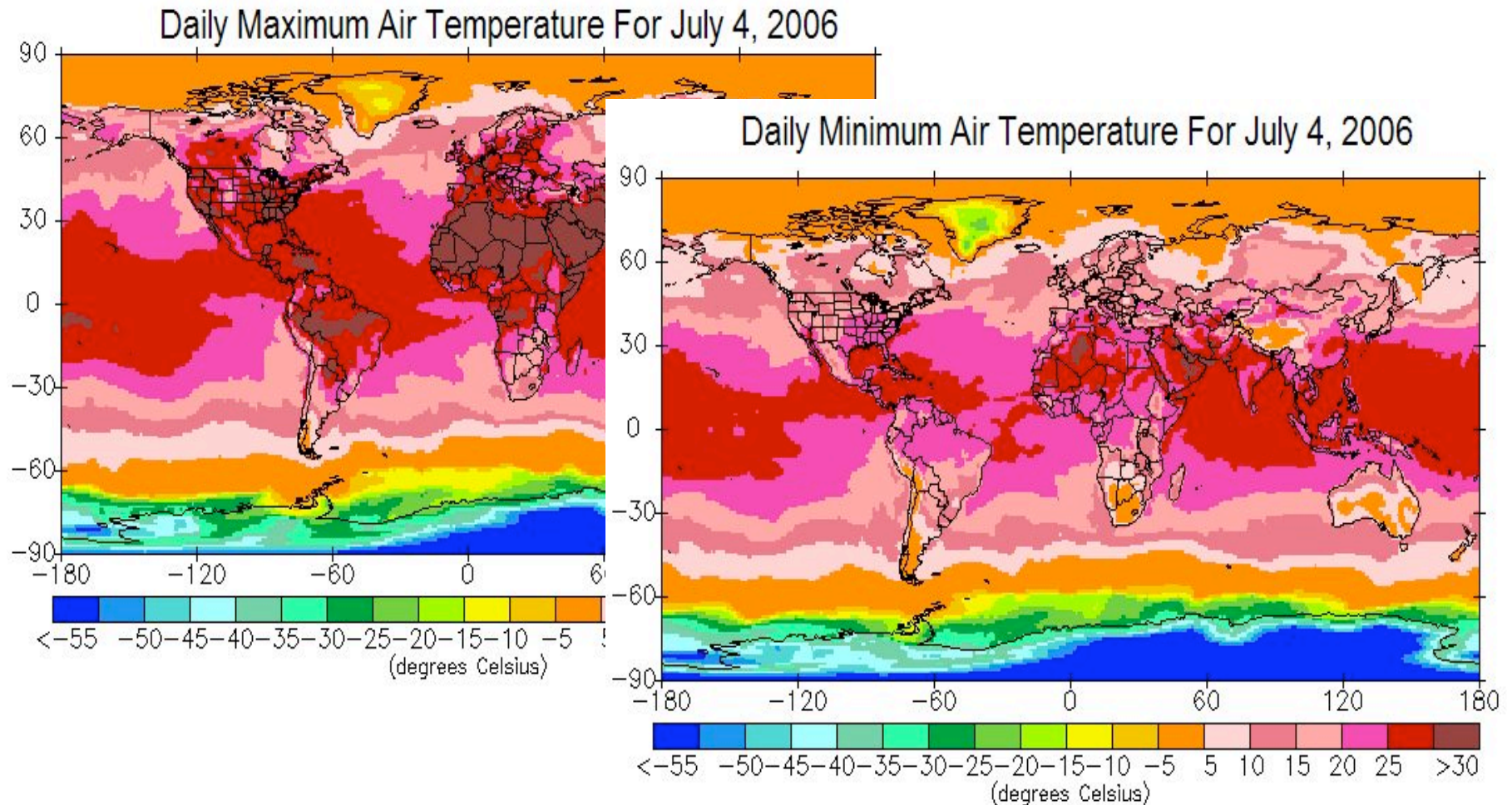
- *How is the global Earth system changing?*
- *What are the primary forcings of the Earth system?*
- *How does the Earth system respond to natural and human-induced changes?*
- *What are the consequences of changes in the Earth system for human civilization?*
- *How well can we predict future changes to the Earth system?*





Relevant NASA Science Data Sets

Meteorological Information from GMAO





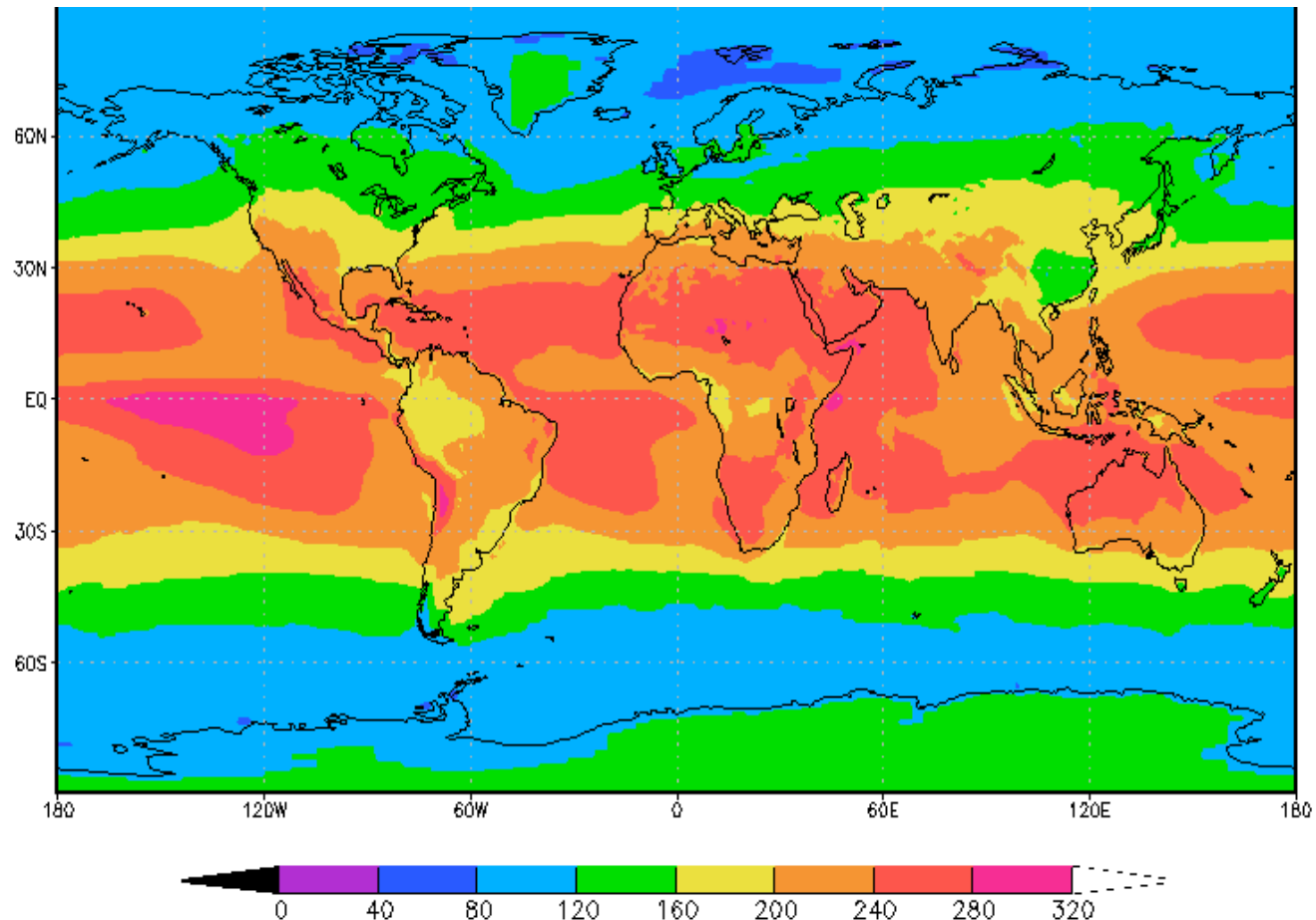
Relevant NASA Science Data Sets

GEWEX Surface Radiation Budget: 24+ years of cloud (from ISCCP), SW and LW fluxes at TOA and Surface

**GEWEX SRB
SW v3.0
(ISCCP, GMAO)**

*24 Year Annual
Average Surface
Solar Fluxes
($W m^{-2}$)*

*(Jan 1984 –
Dec 2007)*

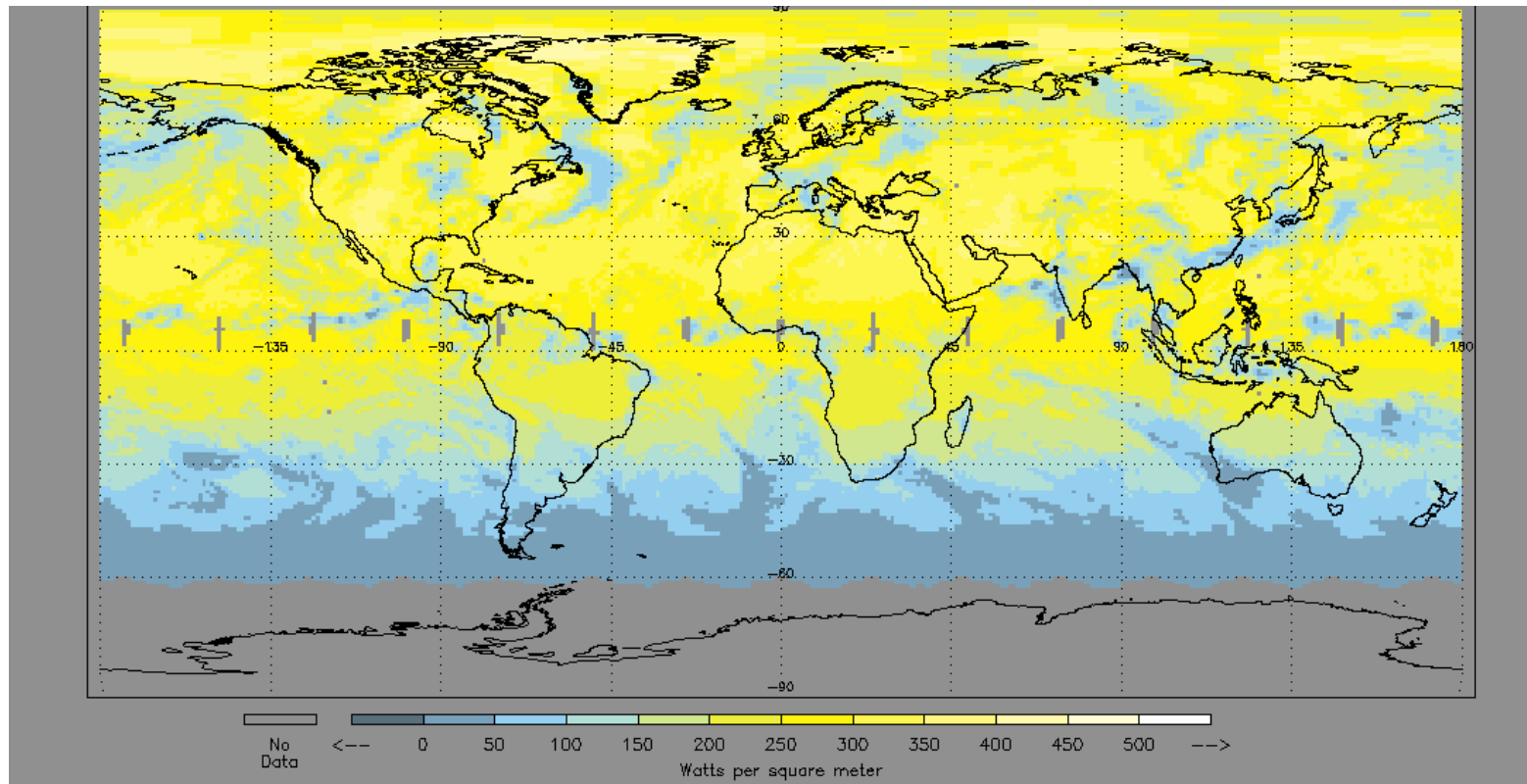




Relevant NASA Science Data Sets

*FLASHFlux: Global TOA and Surface Fluxes within
1 week of observation from Terra and Aqua*

FLASHFlux (CERES/MODIS, GMAO)



Daily Average Solar Irradiance for June 15, 2010 (Wm^{-2})



NASA Applied Sciences Program

- **Applied Sciences Goal:** The Applied Sciences program extends NASA Earth Science research and observations for practical use in environmentally-related decision and policy making.
- **Serves society through:**
 - Demonstrating, through partnerships with public organizations, improvements to their ability to manage and plan natural resources and to make better environmental predictions, decisions, and policy.
- **Serves the Earth science community by:**
 - Demonstrating and communicating the utility and potential of Earth science for societal benefit to a broad audience
 - Complementing R&A programs through applied research in strategic areas
 - Providing the applications “viewpoint” to the research community (e.g., working with GEO and CEOS)
 - Forging partnerships with “nontraditional” organizations (e.g., NREL, USDA, Battelle, NRCAN, ESA, DLR, Universities, Private Sector)



Societal Benefit Areas

Applied Sciences aligns with GEO Societal Benefit Areas, with a focus on those areas where:

- NASA has capability and expertise
- NASA can have greatest impact
- Societal need is greatest



Public Health



Disaster Management



Weather



Water Resources



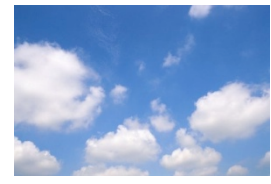
Climate



Agriculture



Ecosystems



Air Quality



Energy Projects in NASA Applied Science

POWER = Prediction of Worldwide Energy Resource

Objective: Improve the Nation's public and private capability for integrating environmental data from NASA's satellite-based analysis and modeling research into sound management of energy production and energy efficiency systems.

Goals:

1. Establish partnerships to facilitate the integration and adaptation of NASA satellite analysis and modeling data into electric power industry Decision Support System's (DSS) and databases.
2. Target such datasets for Electric Power, Renewable Energy, Energy-Efficient Building Design and Biomass Crop Development Industries
3. Transition operational capabilities to government and/or private sector entities.





POWER: Hub for Energy Applications

EARTH SYSTEM MODELS

- Earth System & Climate Change: *GMAO Analysis (GEOS v4.0, v5.1; MERRA)*
- Atmospheric Analysis Projects: *ISCCP, SRB, FLASHFlux (CERES, MODIS), GPCP*

Energy Forecasting

- *MiniCAM (PNNL)*
- *Load Forecasting (Battelle, Ventyx, MSFC)*

Renewable Energy & Energy Efficiency

- *RETScreen (NRCan)*
- *HOMER*
- *IEA Task (NREL)*
- *WMO Buildings*

Selected Proposals

- *Crop-Yield Modeling (USDA, U.Neb., U. Ga)*
- *SWERA 2 (Decisions) (USGS, NREL)*
- *Advance solar mapping (NREL, NCDC, SUNY)*
- *Building Climate Maps (ASHRAE, DOE)*

Data

Data

Data

POWER Prototype Data Set Generation, Validation

Web Prototypes

- *SSE*
- *Sustainable Buildings*
- *Agroclimatology*

EARTH OBSERVATIONS

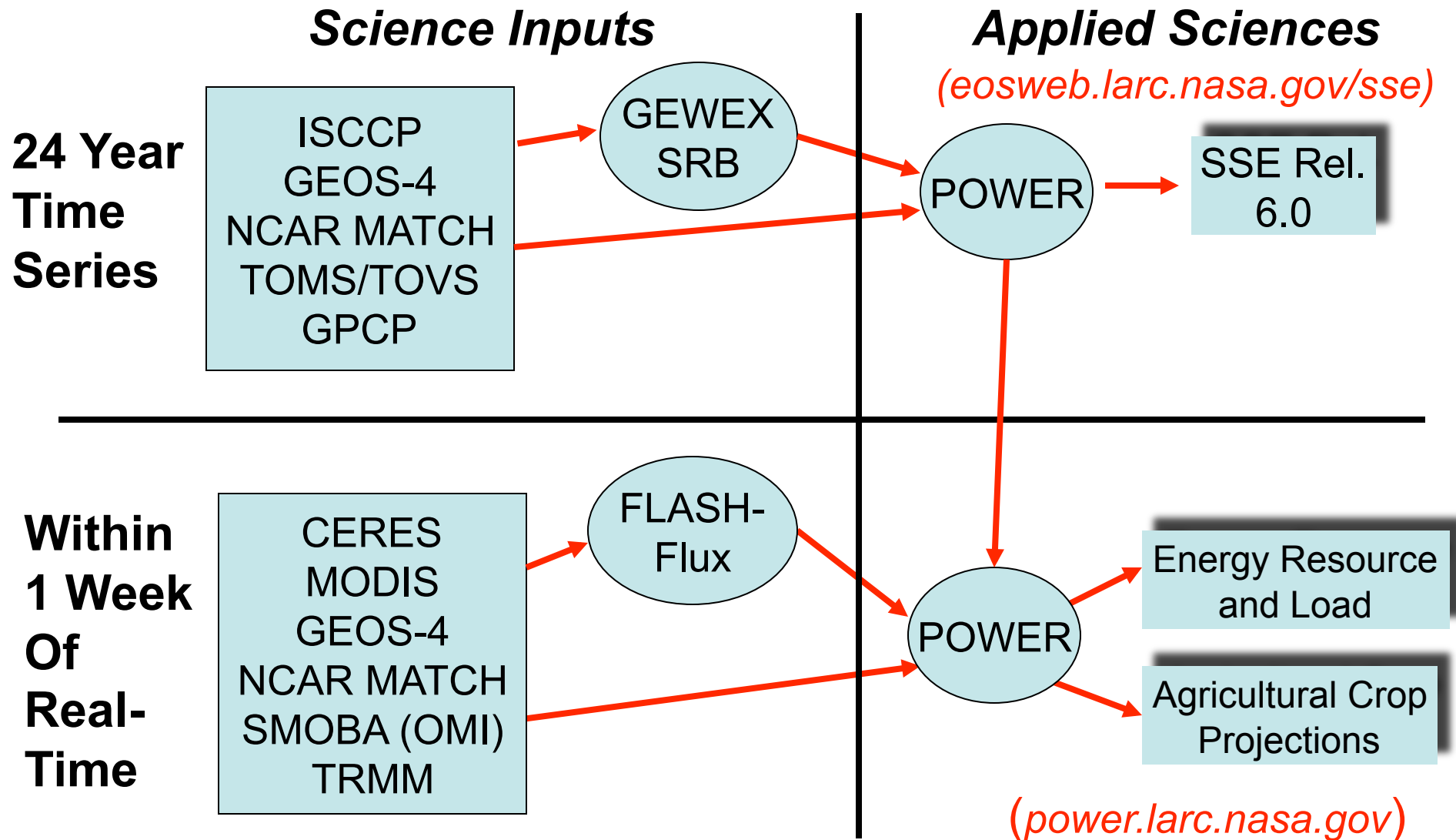
- Satellite: *GOES, POES, TRMM, Terra, Aqua, TOMS, SORCE, Aura, CALIPSO, CloudSat, Glory, GPM, NPP*
- Land: *Aeronet, BSRN, ARM, SURFRAD*

**Future Mission*





Current Data Product Data Flow





NASA SSE Release 6.0

- 23 Years
- New parameters
- Updated Solar algorithm
- Improved validation
- Increased accessibility including regions/time series
- Direct connection to 3 renewable energy DSS tools

<http://eosweb.larc.nasa.gov/sse>

Surface meteorology and Solar Energy

ATMOSPHERIC SCIENCE DATA CENTER

Surface meteorology and Solar Energy

A renewable energy resource web site (release 6.0)
sponsored by NASA's Earth Science Enterprise Program

- over 200 satellite-derived meteorology and solar energy parameters
- monthly averaged from 22 years of data
- data tables for a particular location
- color plots on both global and regional scales
- global solar energy data for 1195 ground sites

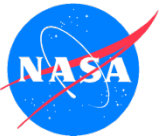
Data Retrieval:

- [Meteorology and Solar Energy](#)
- [Ground Site](#)
- [Renewable Software Application Inputs](#)
HOMER
RETScreen
SolarSizer

Supporting Documentation:

- [Horizontal Grid for Input and Output](#)
- [Accuracy](#)
- [Methodology](#)
- [Parameters \(Units & Definition\)](#)
- [Frequently Asked Questions \(FAQ\)](#)
- [Related Web Sites](#)
- [Join SSE mailing list / Submit Questions](#)
- [Partners and Performance](#)

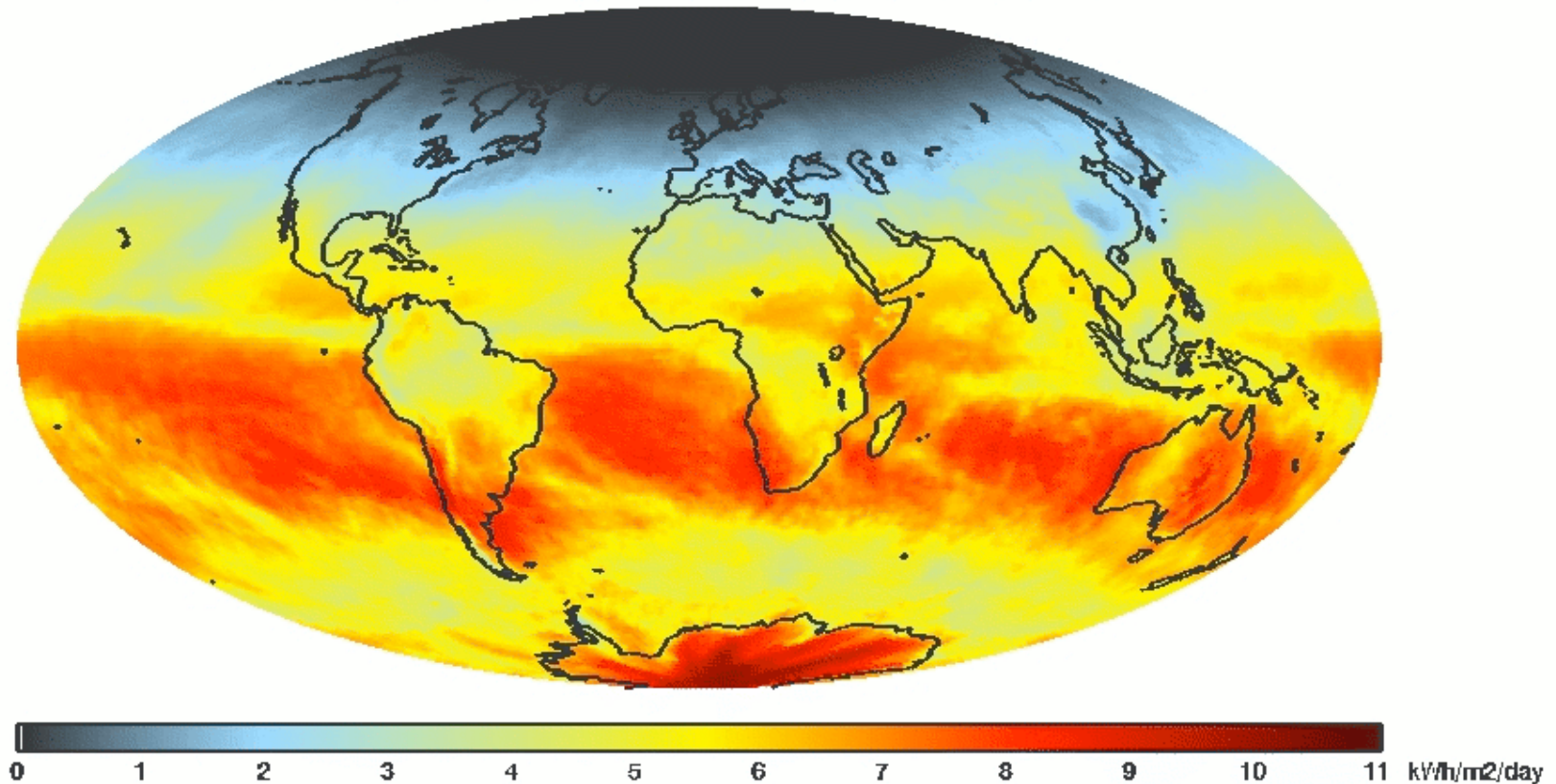
Responsible Officials: Data: [Paul W. Stackhouse, Jr., Ph.D.](#)
[Charles H. Whitlock, Ph.D.](#)
Archive: John M. Kusterer
Site Administration/Help: NASA Langley [ASDC](#) User Services (larc@eos.nasa.gov)
[\[Privacy Policy and Important Notices\]](#)
Document generated on Thu May 1 16:11:40 EDT 2008



Relevant NASA Science Data Sets

Global Monthly Irradiance for 2000 (from GEWEX SRB)

Average Daily Solar Radiation for 2000 Jan





Param

Diurn

Geometry Inform

Meteor

Ge

Pa

Option

Data

Pa

Pa

an

Meteor

Lat 37

Lon -77

Minimum

Maximum

So

Mont

Meteor

Lat 37

Lon -77

22-year Average

Minimum

Maximum

Pa

Pa

Suppo

22-year Average K

Minimum K

Maximum K

Parameters for Sizing Battery or other Energy-storage Systems:

Equivalent Number Of NO-SUN Or BLACK Days (days)

Lat 37 Lon -77	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1 day	0.96	0.95	0.95	0.93	0.91	0.92	0.95	0.89	0.92	0.96	0.94	0.96
3 day	2.61	2.38	2.46	2.66	2.47	1.89	2.16	2.39	2.07	2.37	2.46	2.44
7 day	5.08	4.51	4.53	3.95	4.48	3.33	3.53	3.58	3.61	4.43	3.58	4.11
14 day	7.15	6.14	4.08	5.31	6.77	4.35	3.98	4.95	4.57	5.39	4.74	7.12
21 day	6.19	8.35	5.00	5.24	7.35	4.93	5.12	6.02	3.70	7.40	5.82	8.44
Month	4.60	7.63	3.60	5.26	9.01	3.67	4.27	5.24	4.17	6.81	6.49	6.65

[Parameter Definition](#)

Parameters for Sizing Meteorology (Temperature):

Monthly Averaged Cooling Degree Days Above 18° C

Lat 37 Lon -77	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Sum
22-year Average	0	0	4	22	86	189	257	224	130	34	5	1	952

[Parameter Definition](#)

Meteorology (Wind):

Monthly Averaged Wind Speed At 50 m Above The Surface Of The Earth (m/s)

Lat 37 Lon -77	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
10-year Average	6.60	6.71	6.67	6.04	5.13	4.88	4.34	4.17	4.80	5.38	6.27	6.65	5.63

Minimum And Maximum Difference From Monthly Averaged Wind Speed At 50 m (%)

Lat 37 Lon -77	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Minimum	-13	-11	-14	-10	-13	-11	-10	-16	-8	-11	-8	-11	-11
Maximum	13	8	9	15	16	9	11	10	11	9	10	7	11

It is recommended that users of these wind data review the SSE Methodology. The user may wish to correct for biases as well as local effects within the selected grid region.

All height measurements are from the soil, water, or ice/snow surface instead of "effective" surface, which is usually taken to be near the tops of vegetated canopies.

[Parameter Definition](#)

[Units Conversion Chart](#)



Parameter Validation: Key to Usage

Power validation significant, included in extensive methodology document

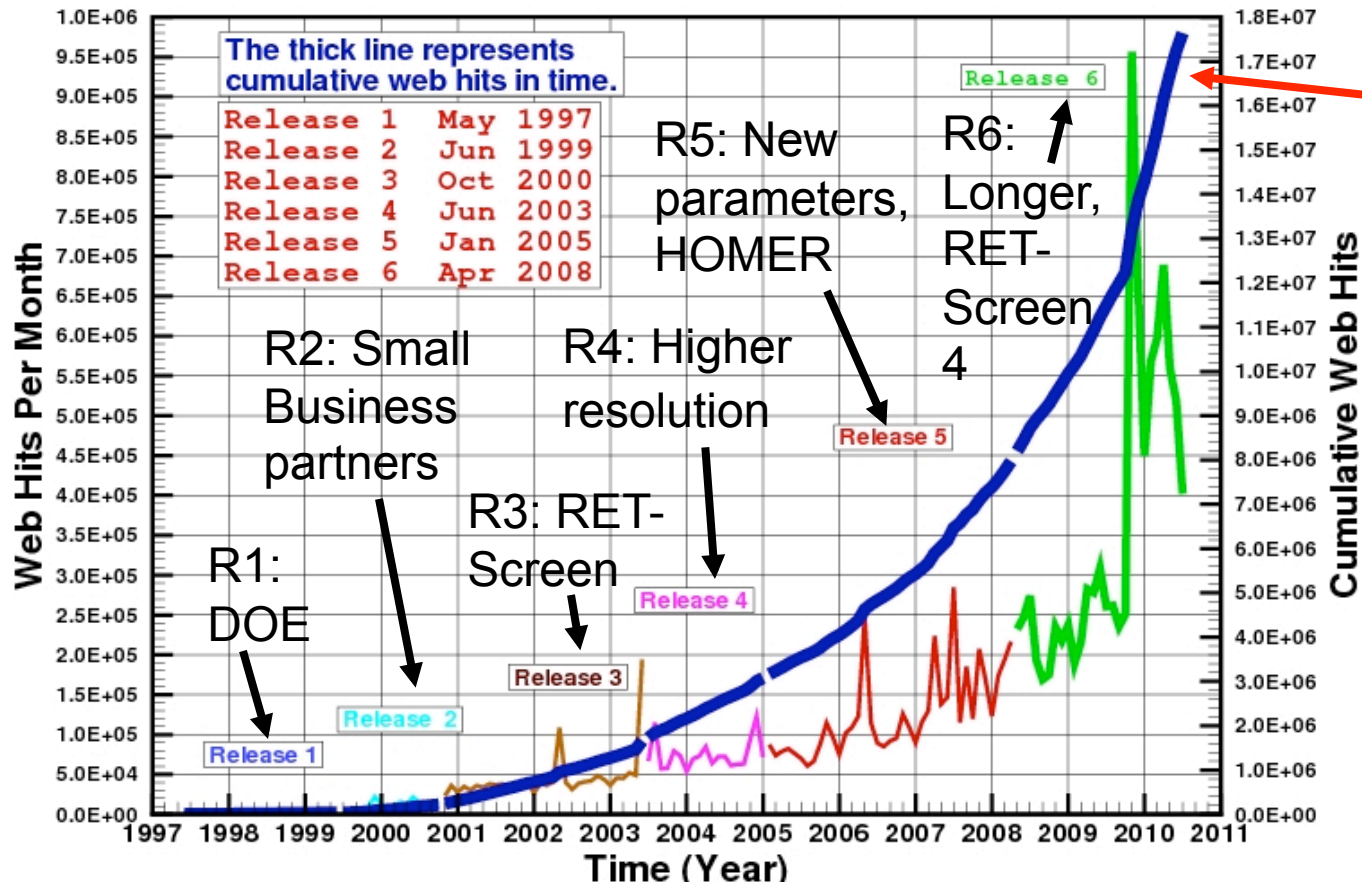
Table I-1: Regression analysis of SSE versus BSRN monthly averaged values for the time

Table I-2: Linear least squares regression analysis of SSE versus NCDC monthly averaged values for the time period 1983 through 2006						
	Parameter	Slope	Intercept	R ²	RMSE	Bias
Hoi	Tmax (°C)	0.00	-1.58	0.05	3.12	-1.83
Table I-3: Estimated uncertainty for monthly averaged wind speed for the time period July 1983 through June 1993						
Hoi	Tmi				Bias	RMSE
	Tav					
	Tde					
Dir	RH	Wind Speed at 10 meters for terrain similar to airports (m/s)	RETScreen Weather Database (documented 10-m height airport sites)		-0.2	1.3
	Hea (deg		RETScreen Weather Database (unknown-height airport sites)		-0.0	1.3
	Cooling Degree Days (degree days)	0.86	2.36	0.92	28.90	-5.65
	Atmospheric Pressure (hPa)	0.89	102.16	0.74	27.33	-10.20



POWER Sustains Growth of SSE Prototype and Web Interface

Surface meteorology and Solar Energy (SSE) Web Interface Usage



> 17.5 million total hits and ~4 million data requests since 1997 inception

Now >75,000+ users, ~2.5X increase since 2007, >1900 new users per month in 2010

Monthly Averaged Usage Statistics

Per Month	Rel. 1	Rel. 2	Rel. 3	Rel. 4	Rel. 5	Rel. 6	Growth
Web Site Hits	1,278	12,533	35,000	74,500	121,180	366,200	285:1
Data Downloads	59	873	3,000	12,530	20,055	98,800	1675:1



Connecting to Decision Tools

Direct Linkage to Building/Renewable Energy Decision Support



[Renewable Software Application Inputs](#)

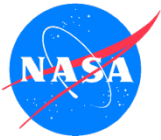
- **HOMER [data access](#)**

The Hybrid Optimization Model for Electric Renewables ([HOMER](#)) is used for designing standalone electric power systems that employ some combination of wind turbines, photovoltaic panels, or diesel generators to produce electricity.

- **RETScreen[®] International [data access](#)**



A collaboration with the CANMET Energy Technology Centre - Varennes (CETC-Varennes) has produced satellite data output useful to users of the RETScreen[®] International Clean Energy Project Analysis Software. [RETScreen[®] International](#) can be obtained free of charge from CETC-Varennes.



RETScreen

www.retscreen.net

- Clean Energy Project Analysis Tool
- Aimed for both feasibility and detailed scenario analysis
- Built on Excel
- Partners since 2000

RETScreen International Home Multilingue

http://www.retscreen.net/ang/home.php

Natural Resources Canada / Ressources naturelles Canada

Canada

Français | Contact Us | Help | Search | Canada Site

Home | Download Free | Training Calendar | Marketplace | NRCan Site

RETScreen® International

Empowering Cleaner Energy Decisions

Overview

Software & Data

Training Course

Training Calendar

Marketplace

Download Free

Help & Contact Us

26 Languages: English - Anglais

LATEST NEWS

155098 users in 222 countries

1,000 new users every week

161 Universities & Colleges active

RSS

CLEAN ENERGY Project Analysis Tools

Energy Efficiency & Renewable Energy

Clean Power, Heating & Cooling

Central-Grid, Isolated-Grid & Off-Grid

Cogeneration & District Energy

Residential, Commercial & Institutional Buildings; Communities; and Industrial Facilities

DOWNLOAD FREE TOOLS

Download RETScreen 4 (26 MB)

Energy Management Magazine - RETScreen Article

The Professional Edge Magazine - RETScreen Article

RETScreen Software Passes 150,000 User Milestone

Managed by CETC-Varenes

NASA | UNEP | GEF | reeep

Created: 2005-01-24

Updated: 2008-04-23

Important Notices



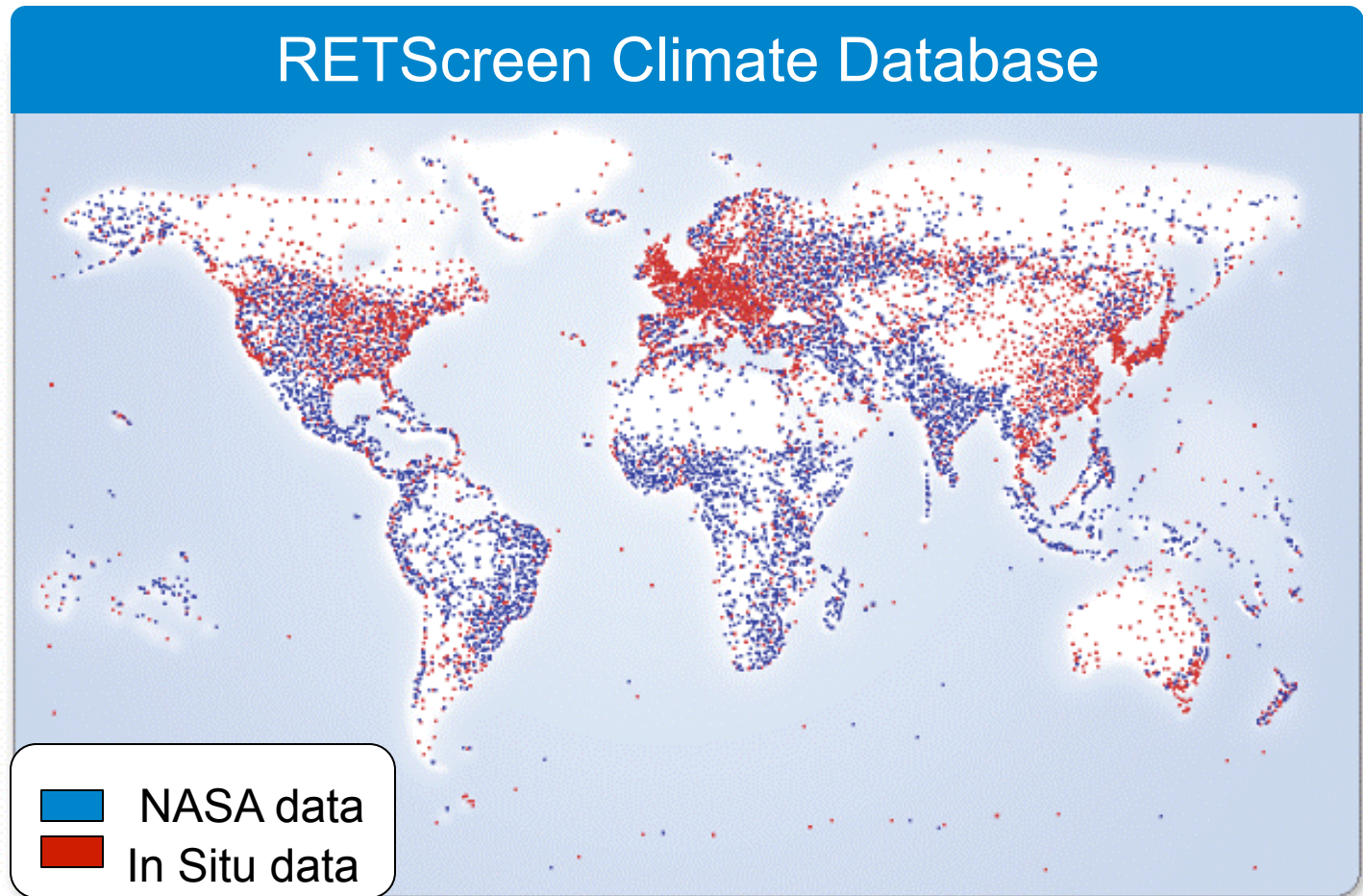
Example RETScreen Clean-Energy Analysis Projects

- **Wind Energy: wind turbines, integration**
- **Small Hydro-Electric Power**
- **Photovoltaic Technology & Applications: household PV, water pumping, grid-tied building integrated PV**
- **Combined Heat and Power: Applications (residential, commercial, building clusters, district energy systems etc.), Fuels (biogas, wood residue, etc.), Equipment (heating and cooling, power generation)**
- **Biomass Heating: wood chip, heating**
- **Solar Air Heating: solar thermal walls**
- **Solar Water Heating: residential and commercial**
- **Passive Solar Heating: illumination angles; windows**
- **Ground Source Heat Pump Tech & Applications**

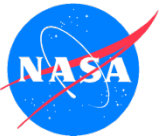


RETScreen's Reliance on POWER Data

- Built-in cities of world
- Direct query of SSE data through web
- 255,000+ users
- 222 countries
- 1000 new users every week
- Release 4: 36 languages



Points represent world's cities (~10,000). Red have in situ observations. Blue defer to NASA LaRC data sets (~5,000). Data for locations between points are found through a direct link to SSE.



Projects Facilitated by RETScreen

RETSCREEN® INTERNATIONAL
Solarwall® on High School in Northern Canada



www.retscreen.net
Solar Water Heating at Vancouver International Airport



Photovoltaic Water Pumping System in Africa



RETScreen

Country: China
 Province / State: Shanghai
 Climate data location: Shanghai

Latitude: °N 31.4
 Longitude: °E 121.5 Source
 Elevation: m 4.0 Ground
 Heating design temperature: °C -0.4 Ground
 Cooling design temperature: °C 33.2 Ground
 Earth temperature amplitude: °C 14.7 NASA

	Air temperature	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
	°F °C	%	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
Jan	45.2	73.0%	2.61	102.5	3.1	5.4	406	0
Feb	49.2	70.4%	3.08	102.4	3.0	6.4	330	0
Mar	49.1	75.1%	3.54	102.0	3.3	9.5	264	0
Apr	59.0	73.9%	4.46	101.5	3.2	14.3	90	150
May	68.9	74.6%	5.05	101.0	3.2	18.9	0	326
Jun	74.8	81.5%	4.64	100.6	3.2	22.8	0	414
Jul	82.6	80.0%	5.15	100.4	3.3	26.6	0	561
Aug	81.9	81.3%	4.82	100.5	3.5	26.6	0	549
Sep	75.9	76.6%	4.09	101.1	3.4	23.1	0	432
Oct	66.7	73.8%	3.47	101.8	2.9	18.4	0	288
Nov	56.3	73.0%	2.91	102.3	3.0	13.2	135	105
Dec	46.0	71.7%	2.56	102.6	2.9	7.7	316	0
Annual	62.2	75.4%	3.87	101.6	3.2	16.1	1,541	2,825
Source	Ground	Ground	NASA	NASA	Ground	NASA	Ground	Ground

Measured at: m 10 0

Five Step Sta

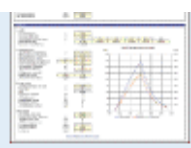


Enter data in shaded cells from top to bottom of each worksheet



Integrated Featu

Climate Data



- Engineering Textbook
- Case Studies
- Marketplace & Maps

Sensitivity & Risk Analysis



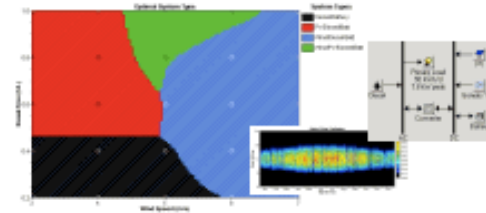
ision

arning Course
erial



HOMER

THE OPTIMIZATION MODEL FOR DISTRIBUTED POWER



New Distribution Process for NREL's HOMER Model

About HOMER

Overview

- User Interface
- Version History
- User Testimonials
- Ask Tom (FAQs)

Downloads

- Software (Visit HOMER Energy)
- Getting Started Guide (PDF File, 720 kB)
- Brochure (English) (PDF File, 964 kB)
- Brochure (Spanish) (PDF File, 1.3 MB)
- Bibliography (PDF File, 47 KB)
- Webcast Materials May 16, 2006

Contact Us

Names and Addresses

Security & Privacy

Note! HOMER is now distributed and supported by [HOMER Energy](http://www.homerenergy.com) (www.homerenergy.com)

To meet the renewable energy industry's system analysis and optimization needs , NREL started developing HOMER in 1993. Since then it has been downloaded free of charge by more than 30,000 individuals, corporations, NGOs, government agencies, and universities worldwide.

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 (DG) applications. HOMER's optimization and sensitivity analysis algorithms allow the user to evaluate the economic and technical feasibility of a large number of technology options and to account for uncertainty in technology costs, energy resource availability, and other variables. HOMER models both conventional and renewable energy technologies:

Power sources:

- solar photovoltaic (PV)
- wind turbine
- run-of-river hydro power
- generator: diesel, gasoline, biogas, alternative
- electric u
- microtur
- fuel cell

Storage:

- battery bank
- hydrogen
- flow batteries
- flywheels

“Best hourly assessment tool for hybrid renewable electric generation systems in the world - bar none.”

Dr. Jan F. Kreider

Building Systems Program, University of Colorado, January 2008



HOMER Example Project



Rural Electrification in the Chiloe Islands

The Chiloe Islands are located off the Pacific Coast of Southern Chile. Of the more than 40 islands in the group, 32 are too far from the coast to be connected to the mainland electric grid and either have no access to electricity, or intermittent access provided by diesel generators. The islands range in size from 12 to 450 homes, with projected loads ranging from 17 to 1004 kWh/day. Economic activity on the islands includes farming, animal husbandry, and fishing. NREL, through a cooperative agreement between the governments of Chile and the United States, worked with a team of local and international experts to implement a pilot hybrid power system on Isla Tac, one of the Chiloe islands. The team conducted economic, loads, and renewable resource studies and used the results from those studies as inputs to HOMER.

The island of Tac, Region de los Lagos, Chile

An optimization analysis using HOMER showed that a wind-diesel system with battery storage would most cost-effectively supply the energy required by the island. HOMER's sensitivity analysis capability helped the team assess the impact of fuel price on the least-cost system design.



Ian Baring-Gould

The Isla Tac Power system provides power to the islands' 82 families.

The team also used two other NREL models: ViPQR to determine electric distribution mini-grid costs, and Hybrid2 to finalize the design of the hybrid power system. This work helped lead to a \$40 million multilateral development bank loan to provide rural electrification projects, including replication of this pilot project, across the entire Chiloe island region.



SWERA 2: Renewable Resources for Developing Nations

- USGS-led ROSES Proposal
- Data archive, user interface at UNEP GRID facility
- *NASA role:* supply global data parameters

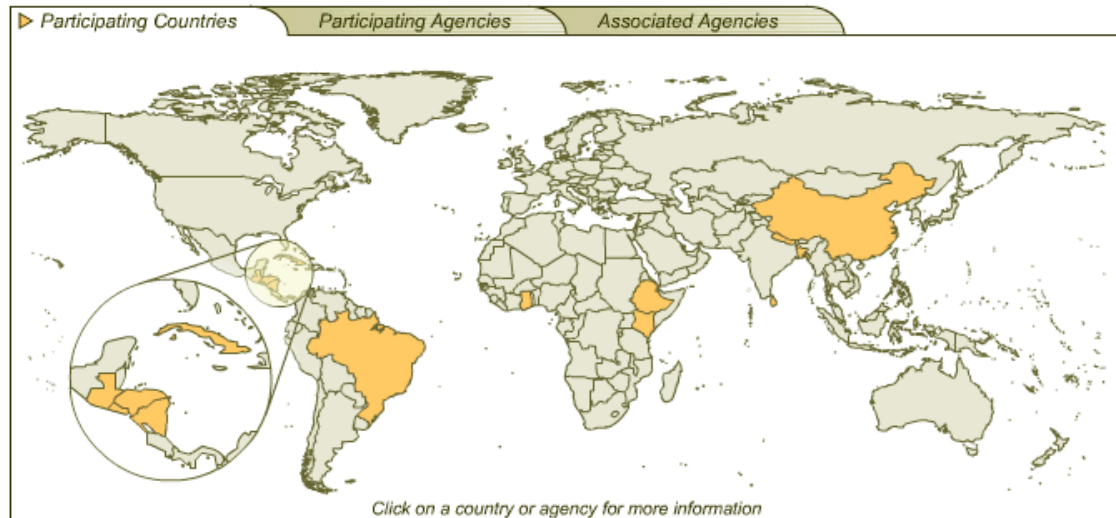
Solar and Wind Energy Resource Assessment

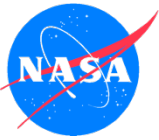


Welcome To SWERA

The **SWERA** website provides information about solar and wind energy resources in thirteen partner countries around the world. Products held in the SWERA archive include data on wind and solar energy potential, plus detailed country energy analyses. To learn more about renewable energy in each country or the partner agencies, click on the map or the menu. SWERA is a UNEP (United Nations Environment Programme) project with co-financing from GEF. The goal is to provide solar and wind energy assessments to potential investors and the public to promote more effective use of alternative energy resources.

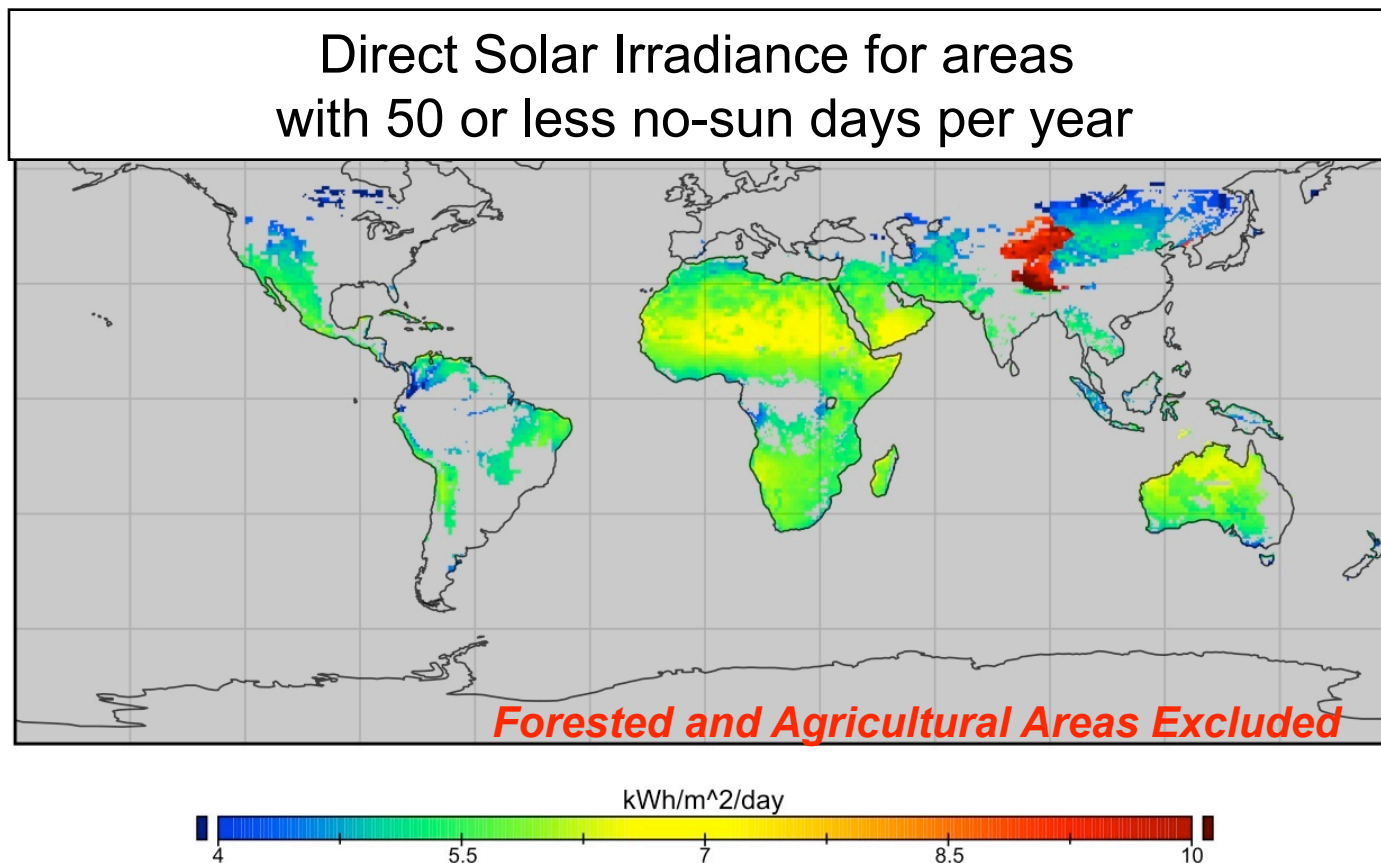
Now with the completion of the successful pilot project, SWERA is being expanded into a full Programme offering resource information and mapping tools across the spectrum of renewable energy sources. All information and tools can be found in one on-line location with a common user interface... click [here](#) for more details.





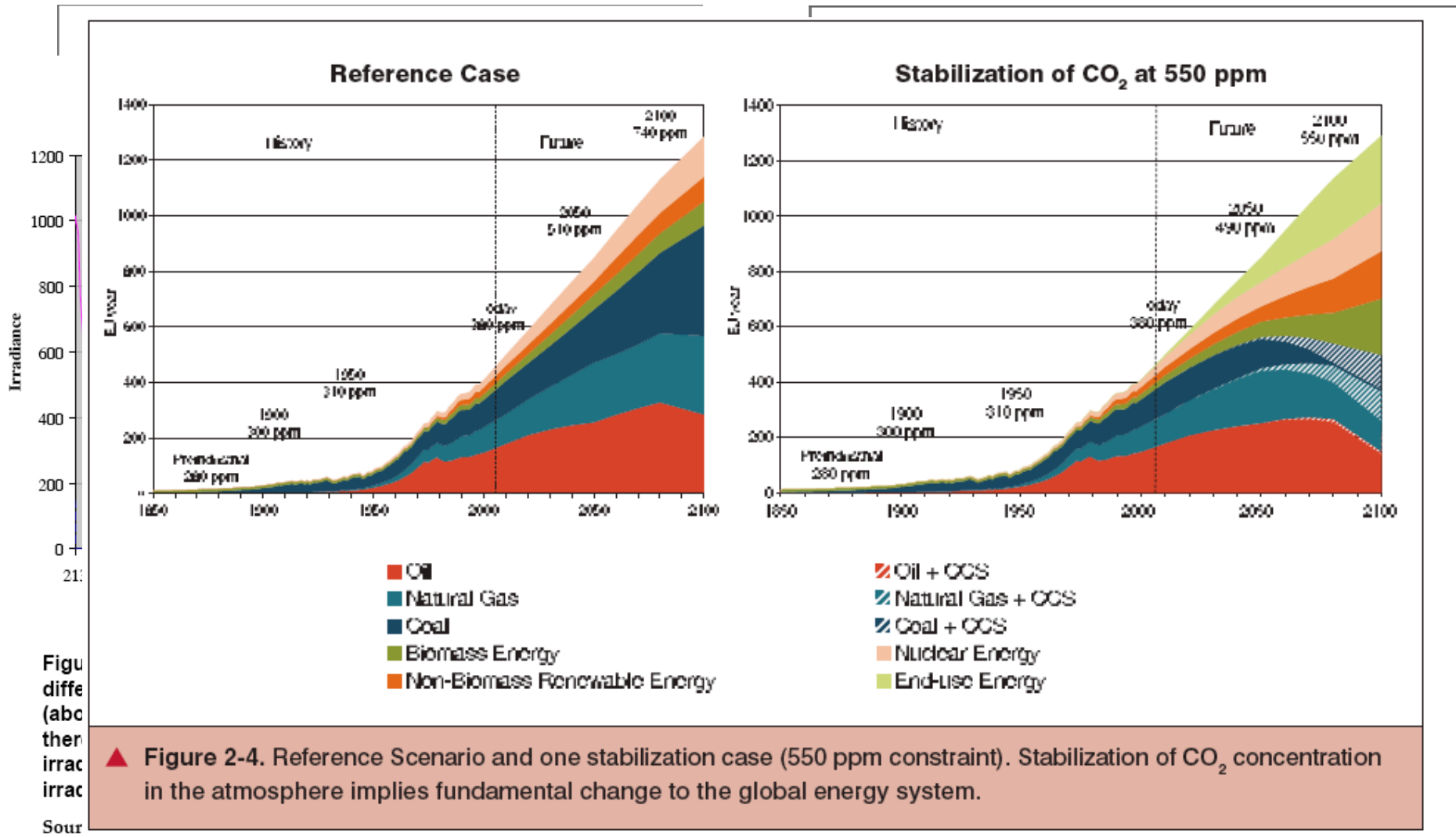
PNNL Integrated Assessment Model Initialization with NASA Data

*PNNL/Joint Global Change Research Center uses NASA
POWER data sets for initiation of MiniCAM 50-year energy
market forecasts for policy planning*





PNNL's Assessment Results





NASA POWER Contributes to International Energy Agency Task

- *International collaboration representing >8 nations; >15 Organizations*
- *5 Year Task*
- *DOE/NREL led*
- *NASA/POWER contributing expertise on solar resource estimation and validation, user and interface information, data sets and research*
- *Result: More accessible and reliable information for solar energy projects*

IEA-SHC || Task 36 – Solar Resource Knowledge Management

http://www.iea-shc.org/task36/index.html

Getting Started Latest Headlines

SHC
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

TASK 36

SHC Home >

Task 36 - Solar Resource Knowledge Management

OVERVIEW

This web site is the official web site of IEA SHC Task 36 "Solar Resource Knowledge Management" - a five-year task initiated by IEA Solar Heating and Cooling Programme Implementing Agreement.

Task Information

Duration
July 1, 2005 to June 30, 2010

Operating Agent
U.S. Department of Energy's National Renewable Energy Laboratory
Dr. David Renné
david_renne@nrel.gov

Task News

Check Back

[What's New](#) | [Objectives](#) | [Scope](#) | [Subtasks](#) | [Task Participants](#) | [Publications](#) | [Task Work Area](#) | [Home](#)

International Energy Agency Solar Heating and Cooling Programme



NASA Energy Program Contributions to GEO and CEOS

- **Core member of GEO energy community of practice**
 - Applied Sciences-funded activities contribute directly to GEO work plan tasks EN06-04, EN07-01, EN07-03
 - IEA activity, leveraged with ESA partnership, provided first **GEO energy early achievement project**, “Solar Information for Developing Countries”
 - One of principal authors of **GEO Energy Strategic Plan**, which closely mirrors Applied Sciences Program plan
 - **Lead for CEOS Energy SBA activities** (GEO-CEOS remapping activities)
 - Energy articles published in **GEO summit publication** (two with NASA involvement)



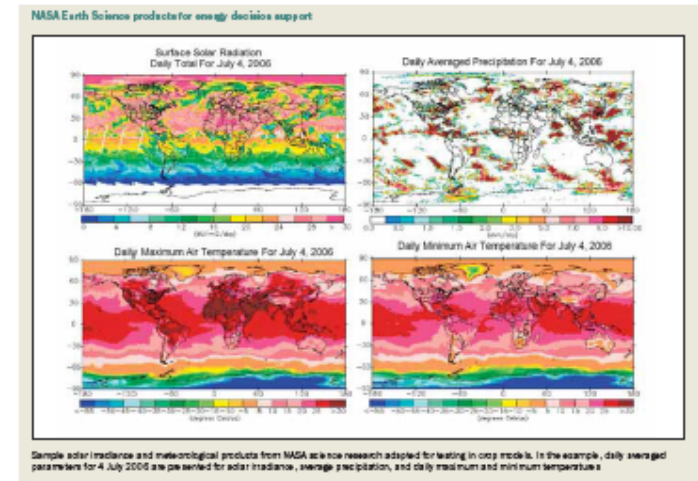
Informing decision making in the energy sector using NASA spaceborne observations and model predictions

Richard S. Eckman and Paul W. Stackhouse, Jr, NASA Langley Research Center

Adapting global sets of spaceborne observations — often made for diverse research purposes — to enhance end-user decision making remains a challenge for the Global Earth Observation System of Systems (GEOS). The US National Aeronautics and Space Administration (NASA) Applied Sciences Program (the Program) seeks to identify innovative uses for NASA-derived spaceborne observations and model predictions and connect with end users to enhance their ability to make management and policy decisions. The Applied Sciences Program's Energy Management application extends NASA Earth science research results to improve decisions and assessments for energy production and energy efficiency, by interacting with partners to benchmark NASA research datasets derived from the analysis of historic and current observations and models to meet energy sector needs. These partners are other government agencies (both domestic and international), academia, professional organizations and the

International Satellite Cloud Climatology Project (ISCCP), Surface Radiation Budget (SRB), Global Modeling and Assimilation Office (GMAO), Goddard Earth Observing System (GEOS) meteorological analysis model, and Langley Research Center FLASHFlux project providing near-real time surface radiative flux.

RETScreen (www.retscreen.net) is a clean energy decision support system, developed by NRC's CANMET Energy Technology Centre, which enables end users to better assess the feasibility of renewable energy and energy efficiency projects, their costs, and greenhouse gas mitigation benefits. Surface solar energy measurements available from ground observations are often sparse or unavailable in the developing world. NASA's satellite-derived global observations and



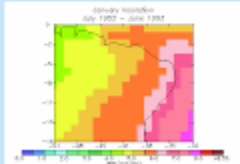
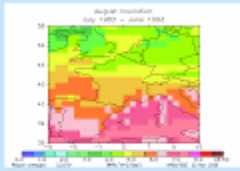
Source: NASA



SSE Data Set



Access through: <http://eosweb.larc.nasa.gov/sse/>

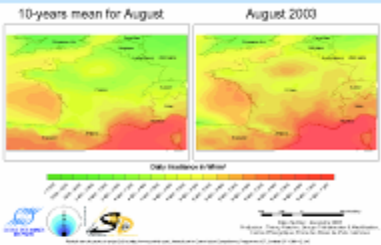


- Monthly averaged from 11 years of data (1983-1993)
- Data tables for a particular location
- Color plots on both global and regional scales
- Over 200 satellite-derived meteorology and solar energy parameters
- Data for the RETScreen® Clean Energy Project Analysis Software

Helioclim Database



Access through SoDa: <http://www.soda-is.com/>



- Database and time-series of irradiance or irradiation
- Produced by the processing of satellite images, especially from the Meteosat series of satellites
- Covering Europe, Africa, the Mediterranean Basin, the Atlantic Ocean and part of the Indian Ocean
- Period runs from 1985 onwards

GEOSS: First Energy Demonstration

The SoDa Service Integrator

The screenshot shows the SoDa Service Integrator interface. At the top left is the URL www.soda-is.com. A code window displays a script for calculating solar irradiance:
$$G_{s0} = I_0 \cdot [\sin(\alpha) \cdot \exp(-0.00012 \cdot T_a \cdot \ln(\text{air})) + \text{Temp}(T_a) \cdot F_{\text{clear}}(T_a)]$$
 Below the code is a map of Europe and Africa. A data plot on the right shows a sinusoidal wave with a peak of approximately 1200 W/m². The interface includes various input fields and buttons for data selection and processing.

Hosted by **École des Mines de Paris**



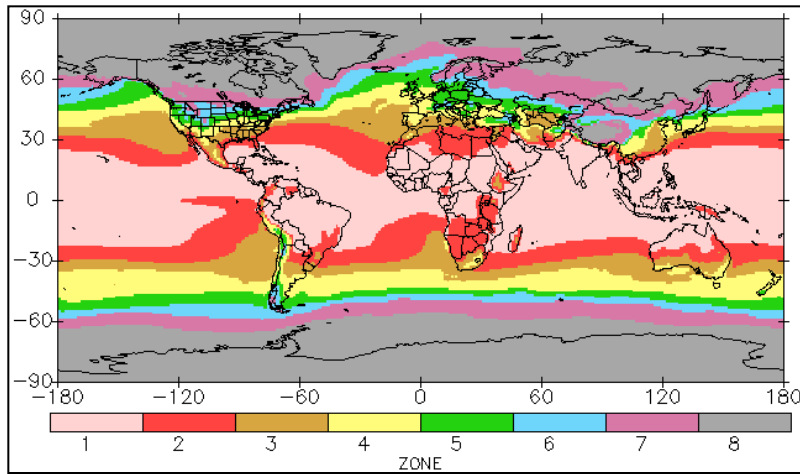
Current and Potential Energy Applications

- ***Building data sets for design (DOE, ASHRAE)***
 - ESSM: GMAO GEOS-4, MERRA, GOCART
 - Satellite-based: GEWEX SRB
- ***Advanced Long-term Solar Mapping (NREL)***
 - Earth System Science models (ESSM): GMAO MERRA, GOCART
 - Satellite-based: ISCCP B1U (w/ 8km pixels), TOVS-TOMS
- ***Building Targeting and Monitoring (NASA, NRCan)***
 - ESSM: GMAO operational assimilation
 - Satellite-based: FLASHFlux
- ***Load Forecasting (Battelle, Ventyx)***
 - ESSM: GMAO operational assimilation, forecasts; SPORT
 - Satellite-based: FLASHFlux
- ***Solar Energy Forecasting (NREL, SUNY)***
 - ESSM: GMAO forecasts
 - Satellite-based: FLASHFlux (for validation)

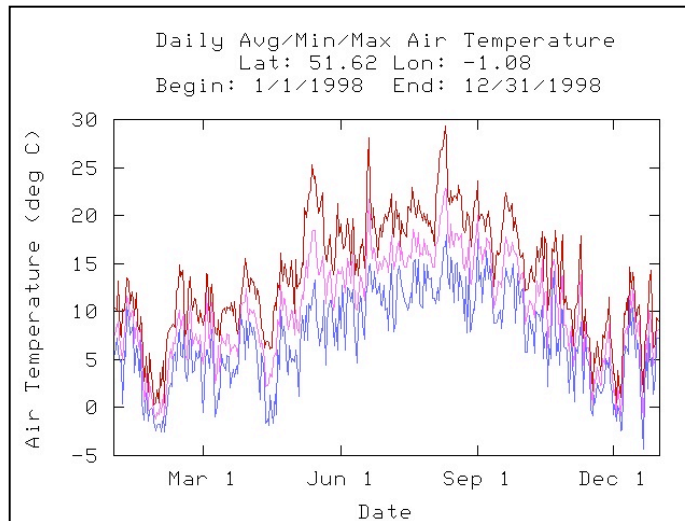


Long-term Climate Information For Building Design

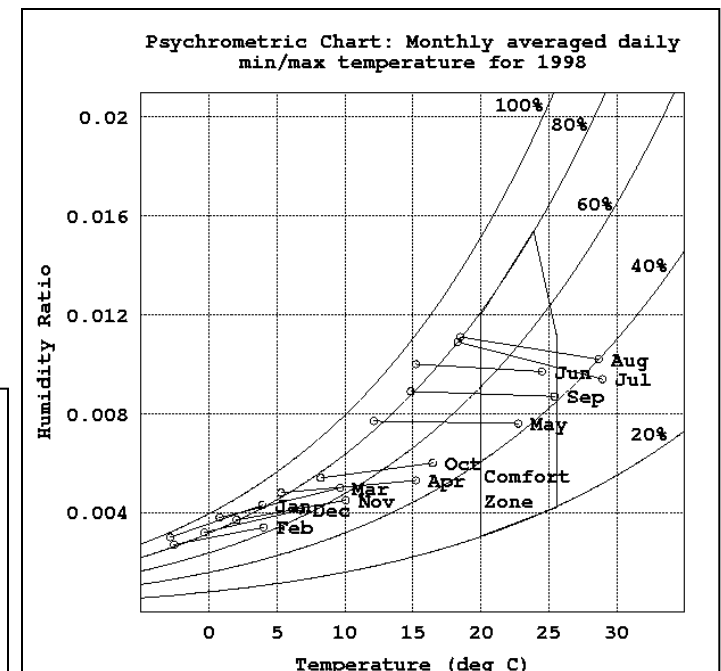
Global Building Design Climate Zones (with ASHRAE and DOE)



**Location
Specific
Daily/Monthly
Averaged
Climate
Information**



Location Specific Traditional Architectural Comfort Zone Design Charts (with AIA)

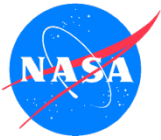


30 Years Needed!



Current and Potential Energy Applications

- ***Building data sets for design (DOE, ASHRAE)***
 - ESSM: GMAO GEOS-4, MERRA, GOCART
 - Satellite-based: GEWEX SRB
- ***Advanced Long-term Solar Mapping (NREL)***
 - Earth System Science models (ESSM): GMAO MERRA, GOCART
 - Satellite-based: ISCCP B1U (w/ 8km pixels), TOVS-TOMS
- ***Building Targeting and Monitoring (NASA, NRCAN)***
 - ESSM: GMAO operational assimilation
 - Satellite-based: FLASHFlux
- ***Load Forecasting (Battelle, Ventyx)***
 - ESSM: GMAO operational assimilation, forecasts; SPORT
 - Satellite-based: FLASHFlux
- ***Solar Energy Forecasting (NREL, SUNY)***
 - ESSM: GMAO forecasts
 - Satellite-based: FLASHFlux (for validation)



Advanced Long-term Solar Mapping

Using newly archived ISCCP B1U and latest long-term H₂O, O₃, aerosol information develop long-term solar maps at high resolution

NOAA Satellite and Information Service
National Environmental Satellite, Data, and Information Service (NESDIS)

National Climatic Data Center
U.S. Department of Commerce

DOC > NOAA > NESDIS > NCDC

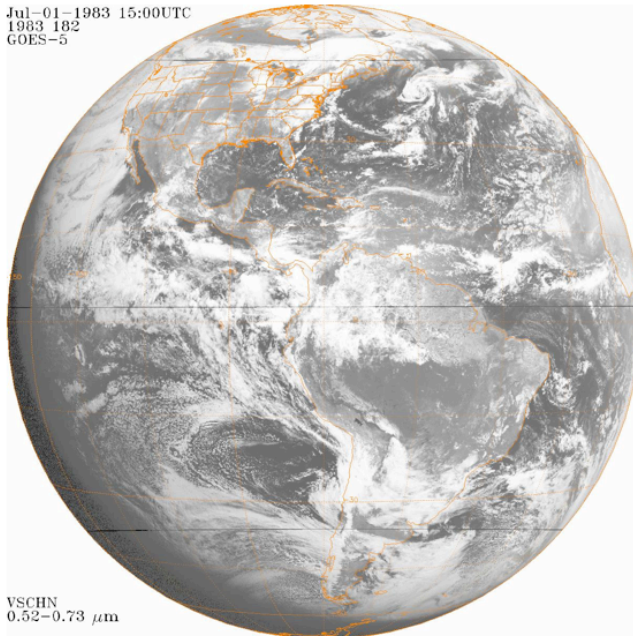
Search Field:

Search NCDC

[Satellite Data](#) > [GIBBS](#) > [1983](#) > [July 01](#)

July 01, 1983 15:00 UTC
Channel: Visible (~0.65um)
Satellite: GOES-5

Jul-01-1983 15:00UTC
1983 182
GOES-5



NOAA Satellite and Information Service
National Environmental Satellite, Data, and Information Service (NESDIS)

National Climatic Data Center
U.S. Department of Commerce

DOC > NOAA > NESDIS > NCDC

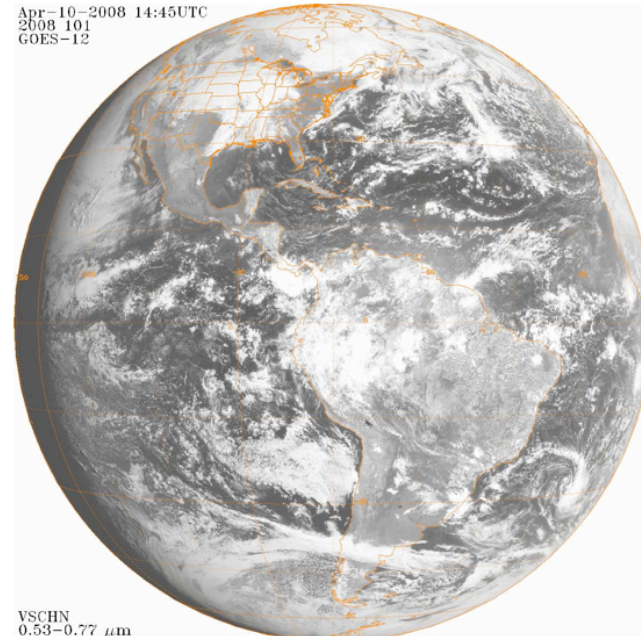
Search Field:

Search NCDC

[Satellite Data](#) > [GIBBS](#) > [2008](#) > [April 10](#)

April 10, 2008 15:00 UTC
Channel: Visible (~0.65um)
Satellite: GOES-12

Apr-10-2008 14:45UTC
2008 101
GOES-12





Current and Potential Energy Applications

- ***Building data sets for design (DOE, ASHRAE)***
 - ESSM: GMAO GEOS-4, MERRA, GOCART
 - Satellite-based: GEWEX SRB
- ***Advanced Long-term Solar Mapping (NREL)***
 - Earth System Science models (ESSM): GMAO MERRA, GOCART
 - Satellite-based: ISCCP B1U (w/ 8km pixels), TOVS-TOMS
- ***Building Targeting and Monitoring (NASA, NRCAN)***
 - ESSM: GMAO operational assimilation
 - Satellite-based: FLASHFlux
- ***Load Forecasting (Battelle, Ventyx)***
 - ESSM: GMAO operational assimilation, forecasts; SPORT
 - Satellite-based: FLASHFlux
- ***Solar Energy Forecasting (NREL, SUNY)***
 - ESSM: GMAO forecasts
 - Satellite-based: FLASHFlux (for validation)



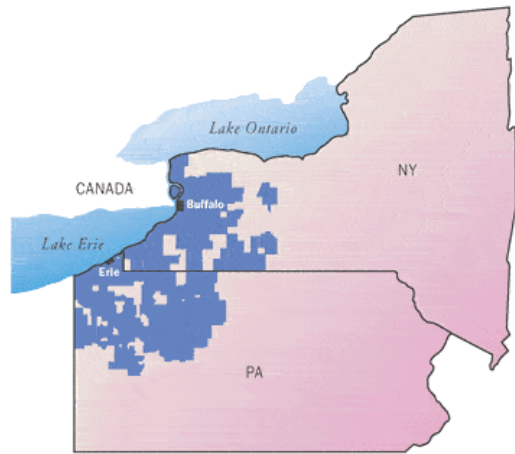
Current and Potential Energy Applications

- ***Building data sets for design (DOE, ASHRAE)***
 - ESSM: GMAO GEOS-4, MERRA, GOCART
 - Satellite-based: GEWEX SRB
 - ***Advanced Long-term Solar Mapping (NREL)***
 - Earth System Science models (ESSM): GMAO MERRA, GOCART
 - Satellite-based: ISCCP B1U (w/ 8km pixels), TOVS-TOMS
 - ***Building Targeting and Monitoring (NASA, NRCan)***
 - ESSM: GMAO operational assimilation
 - Satellite-based: FLASHFlux
 - ***Load Forecasting (Battelle, Ventyx)***
 - ESSM: GMAO operational assimilation, forecasts; SPORT
 - Satellite-based: FLASHFlux
 - ***Solar Energy Forecasting (NREL, SUNY)***
 - ESSM: GMAO forecasts
 - Satellite-based: FLASHFlux (for validation)
-



Energy Forecasting

ROSES proposal w/ Battelle and NewEnergy to evaluation NASA long-term data sets (GMAO) and high resolution forecasts (SPORT)



■ Distribution Corporation Service Area

- Gas utilities use daily averaged data
- Daily averaged 4 years of POWER/FLASHFlux delivered for 4 regions
- Forecast errors reduced
- FLASHFlux data delivered weekly for the Ventyx Vector database

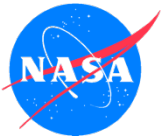
Statistics Overview for Verification Period								
Options								
Group Name	Min MAPE	Max MAPE	Min MPE	Max MPE	Abs Min Err	Abs Max Err	Min % Err	Max % Err
New York Daily	4.07	6.48	-6.48	-1.26	14.15	19875.20	-23.41	5.77
Pennsylvania Daily	7.77	11.81	-146.12	-2.44	.00	.00	.00	.00

Profile Name	MAPE	MPE	Abs Min Err	Abs Max Err	Min % Err	Max % Err	Last Train Date
New York Standard NASA	4.07	-1.26	14.15	7712.64	-8.73	5.77	10/10/2008
New York Standard	6.48	-6.48	405.20	19875.20	-23.41	-.37	10/10/2008




Conclusions

- *NASA Applied Science Program has and continues to yield significant results for nation and international programs through Science => Applications transfer*
- *Successes include supporting renewable energy and energy efficient technology optimization; thus are relevant to identified priorities in climate change mitigation and adaptation.*
- *The model of success in this field has been long-term partnerships featuring the development and dissemination of specifically tailored data sets.*
- *Data sets made available through web based interfaces provide opportunities for new projects and new partnerships*
 - Higher resolution and Hourly data needed!
 - Need for forecasted parameters growing



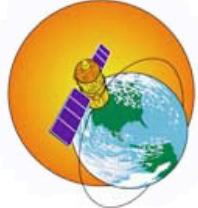
POWER Web Site

<http://power.larc.nasa.gov>



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

[+ Visit NASA.gov](#)



Prediction Of World Energy Resource

Surface meteorology and Solar Energy (SSE-release 5) : A renewable energy resource web site sponsored by NASA's Science Mission Directorate, Earth-Sun System Division, Applied Sciences Program

Earth Science for Society: Accelerating the realization of economic and societal benefits from Earth science, information, and technology ...

[Home](#) [SSE - Renewable Energy Parameters](#) [Sustainable Buildings Parameters](#) [Agroclimatology Parameters](#)

Access Data

- [Data Format](#)
- [SSE - Renewable Energy](#)
- [Sustainable Buildings](#)
- [Agroclimatology](#)

Documentation

- [About the POWER Project](#)
- [About SSE - Renewable Energy](#)
- [About Sustainable Buildings](#)
- [About Biomass Fuel- Agroclimatology](#)
- [Global Geometry/Resolution](#)
- [Parameter Accuracy/Validation](#)
- [Methodology of Satellite Inferred Parameters](#)
- [Power Publications](#)

Related Links


- [Science Mission Directorate](#)
- [NASA's Applications Program](#)
- [Atmospheric Science Data Center](#)
- [Other Related Sites](#)


Navigation and Help

- [Partners](#)
- [POWER Archive Statistics](#)
- [Release Notes](#)
- [Acknowledgments Please](#)
- [Join POWER Mailing List/ Submit Questions](#)
- [FAQs](#)

Processing, archiving, and distributing solar insolation and meteorological parameters

- SSE - RENEWABLE ENERGY:** Satellite-derived data supporting Renewable Energy Technologies (RET's).
 - Over 200 primary and derived meteorology and solar energy parameters
 - Monthly averaged parameters from July 1, 1983 through June 30, 1993
 - Global coverage on a 1° latitude by 1° longitude grid
 - Color plots on both global and regional scales
 - Solar energy data for 1195 ground sites
 - Data for the [RETScreen](#)® Renewable Energy Project Analysis Software
- SUSTAINABLE BUILDINGS:** Satellite-derived data for the preliminary design of buildings and associated renewable-energy power systems.
 - Global coverage on a 1° latitude by 1° longitude grid
 - Twenty Two year monthly averaged temperatures, wind and solar radiation from July 1, 1983 through June 30, 2005
 - Daily averaged solar radiation from July 1983 through June 2005
 - Daily humidity and air temperatures for 1983 and December 2006
 - Temperature and relative humidity on 3-hourly time steps
 - Psychrometer chart and Global and/or regional plots
- AGROCLIMATOLOGY:** Satellite-derived solar and meteorological data supporting agro-technology
 - Global coverage on a 1° latitude by 1° longitude grid
 - Daily total solar radiation from July 1983 through June 2005; and July, 2006 through current with one month delay
 - Daily averaged dew point and air temperatures from January 1983 through December 2006;
 - Daily averaged precipitation from January 1997 - current with two month delay

 [+NASA Privacy Statement, Disclaimer](#)
[+ Freedom of Information Act](#)

 Responsible Official:
Paul W. Stackhouse, Jr., Ph.D.
(e-mail: paul.w.stackhouse@nasa.gov)
Last Updated: Wed May 09 2007 09:42:21 GMT-0400 (EDT)

7/22/2010