SOLAR SPECTRUM

Newsletter of the Resource Applications Division

Volume 19, Issue 1 – May 2006 of the American Solar Energy Society®

Recent Developments in Spectral Irradiance Modeling

by Chris A. Gueymard, Solar Consulting Services

Rapid advances in various spectrally-selective technologies, such as PV and multi-coated glazings, have put a lot of pressure on the solar radiation community to provide demanding measurements of the solar spectrum, as well as appropriate models to predict its variations. Only a very few institutions, such as NREL, are actually measuring spectral irradiance on a permanent basis. Most other institutions measuring the solar spectrum do it for experimental reasons, and therefore on a sporadic basis. Indeed, obtaining good-quality spectra is not easy because considerable resources are required: costly instrumentation, frequent and expensive recalibrations, and highly skilled personnel. All these conditions greatly limit the availability of the reference spectral irradiance databanks that are necessary to serve the development of spectrally-selective technologies. This lack of measurements can be compen-

(Continued on page 8)

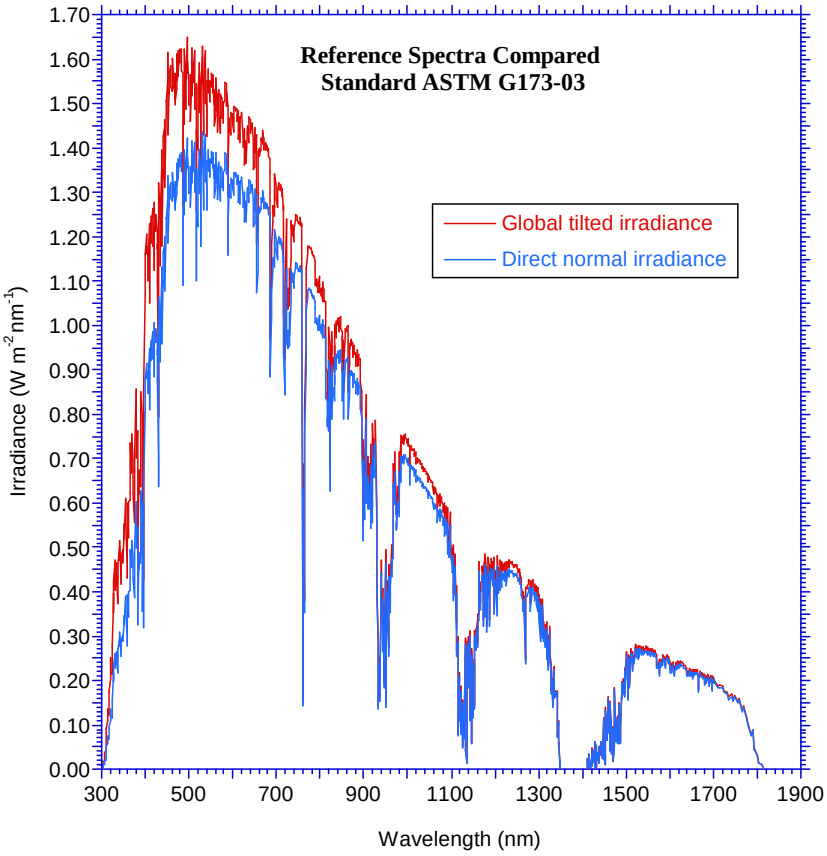

Fig. 1: *Comparison of direct normal irradiance and global irradiance on a 37°-tilted sun-facing surface per ASTM G173-03 standard.*

Inside This Issue

Solar Spectrum is the newsletter from the Resource Applications Division of the American Solar Energy Society and is published on a semi-annual basis. The purpose of this newsletter is to inform division members of events in the resource assessment field and activities of the division and its members.

Success of the newsletter depends on your contributions.

You are encouraged to send comments, letters, or short articles to the Editor:

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I would like to thank Chris Gueymard, Jim Bing, Richard Perez and Steve Wilcox for their contributions to this newsletter.

Deadline for contributions to the next newsletter is October 1, 2006.

Frank Vignola

Resource Applications Division Officers

Jim Bing, Chair
Frank Vignola, Vice Chair
Richard Perez, Secretary

Upcoming Events

Solar 2006
Renewable Energy
Key to Climate Recovery
Denver, Colorado
July 7-13, 2006

Information: ASES
2400 Central Ave., Ste. A
Boulder, CO 80301
P: 303.443.3130
F: 303.443.3212
Email: ases@ases.org
Web: www.ases.org

SOLAR POWER 2006
San Jose, California
October 16-19, 2006

Information: Michelle Brownstein
Phone: 202-682-0556
Email: mbrownstein@seia.org
Web: www.solarpowerconference.com

RAD Division Officers and Board—In transition

The Resource Applications Division of ASES in undergoing re-organization. The makeup of the division and its board will be discussed at the next RAD division meeting at Solar 2006.

The division meeting has been scheduled for **Monday, July 10th between 12:30 and 1:30.** The agenda is on page 4 of this newsletter and there is a discussion of the Resource Applications Division on page 3.

There are many resource application sessions at the Solar 2006. A preliminary listing of some of these sessions is given in an article in this newsletter. The preliminary program schedule can be found on the ASES Website under the 2006 conference.

Email Addresses for Resource Applications Division Members

In order to open communications between RAD division members, the following members circulated their Email address at the RAD division annual meeting. If you are not on this list and would like to add your name to the list, contact Solar Spectrum's editor and your Email address will be added to the list and published in the next newsletter.

Please notify the editor of changes.

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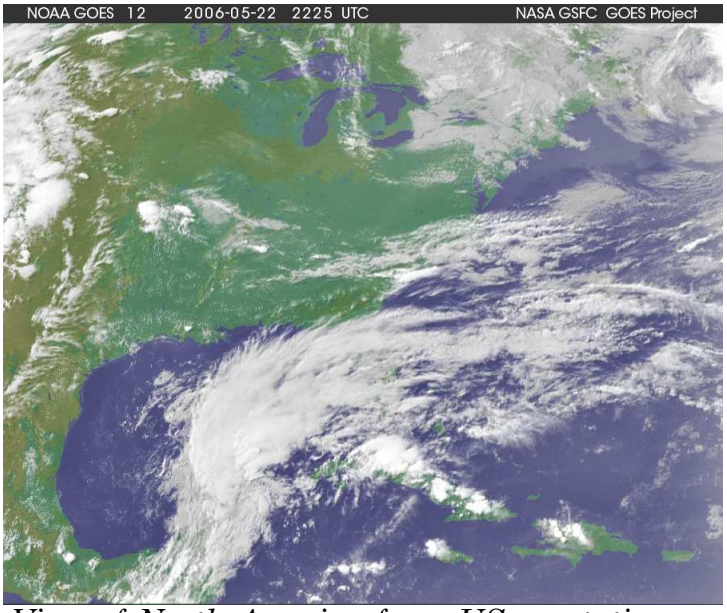
Resource Application Division

by Richard Perez

The Resource Applications Division is a forum for scientists and solar professionals to meet and discuss all that is current and relevant in the field of solar resource assessment technology, its applications and its implications for our industry, our economy, our environment and our planet as a whole. We study atmospheric physics and the effects of changing meteorological conditions on the delivery of the sun's energy to the earth's surface. We do predictive modeling of effects of near-term –weather-- and long-term –climate-- phenomena on solar energy. Some of our members specialize in sensors used for solar radiation detection, studying them at the level of device optics and semiconductor physics. Others explore the application and accuracy of satellite photography, viewing earth images of hundreds of thousands of square kilometers at a time. We are atmospheric physicists, meteorologists, and electrical-mechanical-software engineers. Members are from academia, private industry, and the national laboratories.

The science of solar resource monitoring and assessment has evolved over the last fifty year from ground based analog recorders and qualitative assessment by trained observers, to highly sensitive and automated radiation detecting apparatus and ever higher resolution satellite imagery. The simulation and analysis tools available to the solar system designer and central station solar plant operator are based in this science and the amassed field data that it has produced. The common thread that runs through all of the work of members of Resource Applications Division is the pursuit of the understanding and quantification of how and when the sun's energy is transmitted from the outer atmosphere to the surface of our planet.

http://www.asrc.cestm.albany.edu/perez/



View of North America from US geostationary weather satellites (GOES). http://goes.gsfc.nasa.gov/

Resource Applications Division Annual Meeting

by Jim Bing

Please join us at the Resource Applications Division meeting during the American Solar Energy Society annual meeting in Denver. The meeting will be held on Monday, July 10th between 12:30 and 1:30. The agenda will be as follows:

1) Division elections: chair, vice chair, secretary/ treasurer, executive board.

2) Appointment of a 2007 Technical Review Committee Member to represent the Resource Applications Division at the meeting to select 2007 papers for presentation.

3) Solicit papers for the technical conference.

4) Solicit reviewers with their areas of competence for technical papers.

5) Ratify changes to the Resources Applications Division By-laws. Several changes have been voted in the annual meetings of the past several years which are not reflected in the most current version of the by-laws. These changes include a change of the Division name from "Resource Assessment" to "Resource Applications," and an increase of the term of officers from one year to two years. A copy of the updated by-laws will be distributed prior to the meeting in July.

6) Establish a committee to develop and promote the next Technical Forums that the Resource Applications Division wishes to present.

4) In addition, Resource Applications gets to nominate two or more candidates to run for a seat on the ASES Board of Directors. The successful candidate will be elected by the general ASES membership to replace Paul Notari who is phasing off the Board this year. Board member will serve for three years, and can attend (most) of the three annual board meetings, at his/her own expense (or that of their organization, not of ASES). The meetings are held, one in Boulder, one immediately following the Annual meeting, and one somewhere else. The Boulder meeting is also a 2 day retreat followed by the Board meeting.

Board meetings are basically all day affairs, at which each member is expected to participate actively. In addition, each member is expected to be active on several of the dozen or so committees of the Board, and during their tenure, be a chair of one committee. Continuing activities are to provide strategic direction to ASES, to assist in fund raising and to use existing contacts to identify prospective donors, to assist ASES in meeting its goals, and to serve the membership.

8) Solicit article contributions and a volunteer to assist the newsletter editor with next year's editions.

If you are unable to attend the meeting in July and wish to volunteer for any of the tasks mentioned above or care to express an opinion please do so by contacting me at jbing@newenergyoptions.com.

(Please put "Resource Applications Division" in the subject line of any emails.)

Or write to:

American Solar Energy Society
Resource Applications Division
2400 Central Ave., Ste. A,
Boulder, CO 80301

Looking forward to seeing you in Denver,

James Bing

Chair, Resource Applications Division

Renewable Application Sessions at Solar 2006

The following is a preliminary listing of renewable application sessions at Solar 2006.

Monday 10:30—Noon

Solar Radiation Data and Models

Session Chair: Jim Augustyn, Augustyn + Company

A Study to Assess Solar Energy Potential Striking Existing Urban Rooftops in Honolulu, Hawaii
S. Meder and O. Pennetier, University of Hawaii

Cloudy Sky Version of Bird's Broadband Hourly Clear Sky Model
D. Myers, National Renewable Energy Laboratory

Removing Systematic Errors from Rotating Shadowband Pyranometer Data
F. Vignola, University of Oregon Solar Radiation Lab

Prediction and Validation of Cloudless Shortwave Irradiance Spectra for Horizontal, Tilted, or Tracking Receivers
C. Gueymard, Solar Consulting Services

Monday 2:00—3:30

Resource Assessment and Forecasting

Session Chair: Richard Meyer, DLR

Solar Resource Knowledge Management: A New Task of the International Energy Agency
D. Renné, National Renewable Energy Laboratory; H. Beyer, Institut für Elektrotechnik, GERMANY; L. Wald, Centre Energetique et Procedes, FRANCE; R. Meyer, DLR - Oberpfaffenhofen, GERMANY; R. Perez, ASRC, The University at Albany and P. Stackhouse, NASA Langley Research Center

Irradiance Forecasting for the Management of Solar Energy Systems
D. Heinemann, E. Lorenz and M. Girodo, Oldenburg University, GERMANY

Independent Validation of NDFD-Based Solar Radiation Forecasts
R. Perez, ASRC, The University at Albany; K. Moore, Integrated Environmental Data and P. Stackhouse, NASA Langley Research Center

Towards Production of an Updated National Solar Radiation Data Base
S. Wilcox, M. Anderberg, R. George, W. Marion, D. Myers and D. Renné, National Renewable Energy Laboratory; W. Beckman, University of Wisconsin, Madison; A. DeGaetano, Northeast Regional Climate Center; G. Gueymard, Solar Consulting Services; R. Perez, State University of New York at Albany; N. Lott, National Climatic Data Center; P. Stackhouse, NASA Langley Research Center and F. Vignola, University of Oregon Solar Radiation Lab

2:00—3:30 Monday

Forum: Tutorial on Measurement Systems for Concentrated Sunlight

Moderator: Andreas Neumann, German Aerospace Center DLR

This tutorial is geared toward scientists and students who work with concentrated sunlight, ranging from a few suns up to many thousand suns for high temperature applications. The tutorial will start with basics like blackbody radiation; the sun and the solar spectrum, basic optics, and concentrating solar systems. We will describe measurement tasks on solar concentrators and solar receivers; and furthermore show temperature measurement methods including thermocouples, RTD's, thermistors, pyrometers and infrared cameras. A few words will be said about measurement of terrestrial solar radiation including global and direct normal radiation. The tutorial will show special instruments and measurement systems for concentrated solar radiation. This includes measurement problems, radiometer, calorimeter, camera and target techniques.

Presentations Include:

Basic, Systems, and New Approaches at DLR
Andreas Neumann, German Aerospace Center DLR

Status of Measurement Systems at NREL
Carl Bingham, National Renewable Energy Lab.

Tuesday 2:00 – 3:30

Forum: Solar Resource Monitoring: Career Perspectives

Moderator: James M. Bing, New Energy Options, Inc.

The science of solar resource monitoring and assessment has evolved rapidly over the last fifty years. It has transitioned from ground based analog recorders and qualitative assessment by trained observers, to ever higher resolution satellite imagery. The simulation and analysis tools available to the solar system designer and central station solar plant operator are based in this science and the amassed field data that it has produced. This forum brings together researchers from academia, private industry, and the national laboratories to provide an overview of the trends in the science and technology of solar resource assessment that they have witnessed in their careers and an appraisal of the future direction of the field.

Speakers include:

Stephen Wilcox, National Renewable Energy Laboratory

Frank E. Vignola, University of Oregon, Department of

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Federal Legislation for Resource Assessment

by Frank Vignola

When the energy bill was passed in EPAct 2005 legislation it contained a provision for the assessment of renewable energy resources. This was authorization legislation, but did not appropriate funds.

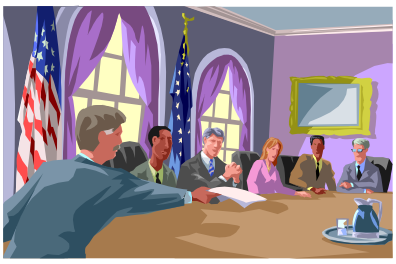
To support resource assessment activities write to your Congressional representatives and ask them to make sure that funds are appropriated for resource assessment in Sec 201 of the Energy Policy Act of 2005.

Subtitle A--General Provisions

SEC. 201. ASSESMENT OF RENEWABLE ENERGY RESOURCES.

(a) RESOURCE ASSESSMENTS- Not later than 180 days after the date of enactment of this Act and each year thereafter, the Secretary shall--

(1) review the available assessments of renewable energy resources within the United States, including solar, wind, biomass, ocean (tidal, wave, current, and thermal), geothermal, and hydroelectric energy resources; and



(2) undertake new assessments as necessary, taking into account changes in market conditions, available technologies, and other relevant factors.

(b) REPORTS-

(1) IN GENERAL- Not later than 1 year after the date of enactment of this Act and each year thereafter, the Secretary shall publish a report based on the most recent assessment under subsection (a).

(2) CONTENTS- The report shall contain--

(A) a detailed inventory describing the available quantity and characteristics of the renewable energy resources; and

(B) such other information as the Secretary determines would be useful in developing the renewable energy resources, including--

(i) descriptions of surrounding terrain, population and load centers, nearby energy infrastructure, and the location of energy and water resources;

(ii) available estimates of the costs needed to develop each resource;

(iii) an identification of any barriers to providing adequate transmission for remote sources of renewable energy resources to current and emerging markets;

(iv) recommendations for removing or addressing those barriers; and

(v) recommendations for providing access to the electrical grid that do not unfairly disadvantage renewable or other energy producers.

(c) AUTHORIZATION OF APPROPRIATIONS-

There are authorized to be appropriated to the Secretary to carry out this section $10,000,000 for each of fiscal years 2006 through 2010.

Introduction to Solar Radiation Monitoring

National Renewable Energy Laboratory
Golden, Colorado
Sunday July 9th, 2006
8:30 a.m. to 5:30 p.m.

The Resource Application Division of ASES is holding a workshop on the "Introduction to Solar Radiation Monitoring". The workshop is designed for those interested in measuring the solar resource and will be presented by experts from the Resource Application Division and the National Renewable Energy Laboratory. This is an opportunity to get the latest information about solar monitoring and a chance to ask questions and learn from the experts. Registration fee is $175 by June 1, 2006 and $200 afterwards.

A bus will leave the conference hotel and take people to NREL for the workshop.

Workshop Agenda

8:30 – 8:45 **Badging at NREL Site Entrance Building, escort to NREL SERF Auditorium**

8:45 – 9:00 **Introduction, schedule overview, meeting logistics, etc.**

9:00 – 10:00 **Solar Measurement basics** (*Stoffel*, Vignola)

a. The solar measurement domain (terms, geometry, parameters)
b. Instrumentation (type, principles, accuracy)

10:00 – 10:15 **Break**

10:15 – 11:15 **Measurement Fundamentals** (*Vignola*, Augustyn)

a. Setting up measurement stations
b. Routine operations/ Maintenance
c. Pitfalls

11:15 – 11:45 **Escort/travel to the Solar Radiation Research Laboratory (SRRL)**

11:45 – 12:30 **Box lunch at SRRL (provided)**

12:30 – 1:30 **Tour of the SRRL** (*Stoffel*, Myers, Wilcox)

a. SRRL mission and operations
b. Measurements
c. Metrology Lab
d. Data distribution

1:30 – 1:45 **Escort/travel from SRRL back to auditorium**

1:45 – 2:45 **Data Analysis and Quality Assessment** (*Augustyn*, Wilcox)

a. Tools
b. Techniques

2:45 – 3:45 **Calibrations** (*Myers*, Wilcox)

a. Necessity
b. Traceability
c. Methods

3:45 – 4:00 **Break**

4:00 – 5:15 **Real life experience – discussion among participants**

5:15 – 5:30 **Return to NREL site entrance building and check out**

Presenters:

Jim Augustyn, Augustyn+ Company—ran the PG&E solar monitoring network and developed data analysis and archival software

Daryl Myers, NREL—runs NREL solar monitoring for PVs with a long career in solar monitor

Tom Stoffel, NREL—runs NREL SRRL facility and work closely with the WMO's World Radiation Reference efforts, BSRN, and ARM.

Frank Vignola, University of Oregon—runs the UO Solar Radiation Monitoring Network

Steve Wilcox, NREL—oversee NREL's efforts to update the National Solar Radiation Data Base.

For more information go to the ASES Website at www.ases.org or phone (303) 443-3130

Meteorological station in Odeillo, France.
Photo by Chris Gueymard

Recent Developments in Spectral Irradiance Modeling

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sated for in large part by the use of appropriate radiative transfer models. A variety of such models have been developed for the needs of atmospheric scientists and of the remote sensing and climate change communities. Examples of such models include MODTRAN, SBDART, libRadtran, and 6S. There are many reasons, however, why such models are not convenient for the engineering applications envisioned here. One essential drawback of these models, besides their complexity and considerable execution time, is that they do not address the essential case of spectral irradiance incident on tilted surfaces.

The SMARTS Model

Now in its 15th year of development, the SMARTS model's conceptual idea has always been to offer fast and accurate predictions of spectral irradiance on any tilted surface without the difficulties and limitations associated with the atmospheric models mentioned above. The SMARTS model is now used by an estimated 800 scientists and students worldwide, for a large variety of applications. This is actually made possible by the model's versatility, which has been discussed in a recent scientific paper. Although the model currently accommodates the case of cloudless skies only, it is hoped that funding will become eventually available to expand its scope through the development of an all-sky version, which could be used to simulate the yearly performance of spectrally-selective devices, for instance. Version 2.9.2 of the model is freely available in two different packages (PC and Mac-Classic) from http://rredc.nrel.gov/solar/models/SMARTS/. A newer, improved, and much expanded version, 2.9.5, has recently become available for three platforms (PC, Mac-OSX and Linux).

Solar Oven in Odeillo, France

Standards

A few reference spectra, based on SMARTS version 2.9.2, have already been standardized for various applications. Most useful to the solar energy community in general should be standard ASTM G173-03 "STANDARD TABLES FOR REFERENCE SOLAR SPECTRAL IRRADIANCES: DIRECT NORMAL AND HEMISPHERICAL ON 37º TILTED SURFACE", available for purchase from http://www.astm.org. This standard replaces the older G159, which itself replaced both E891 and E892, first issued about 25 years ago. Standard G173 offers a lot more accuracy and spectral resolution than the spectra it replaces. Although the new and old global spectra on a 37º sun-facing tilt are closely comparable in magnitude, the new direct normal spectrum is noticeably enhanced compared to the older versions. This result conforms to the request of the concentrating solar power industry, which is targeting very clear areas of the world for the siting of solar power plants. An edited

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version of the global tilted spectrum in G173 will also be used by the International Electrotechnic Commission as standard IEC 60904-3 "MEASUREMENT PRINCIPLES FOR TERRESTRIAL PHOTOVOLTAIC (PV) SOLAR DEVICES WITH REFERENCE SPECTRAL IRRADIANCE DATA", currently in its final stages of adoption. For applications related to the degradation of materials, ASTM has also adopted standard G177-03 "STANDARD TABLES FOR REFERENCE SOLAR ULTRAVIOLET SPECTRAL DISTRIBUTIONS: HEMISPHERICAL ON 37° TILTED SURFACE", which is limited to the 280–400 nm waveband, with a considerably increased magnitude compared to the UV part of the G173 global spectrum. Finally, there is preliminary activity at the Commission Internationale de l'Eclairage (CIE) to develop SMARTS-based reference spectra for lighting and daylighting purposes. For illustration purposes, the two reference spectra of G173 appear in Fig.1, whereas the UV global spectra from G173 and G177 are compared in Fig. 2.

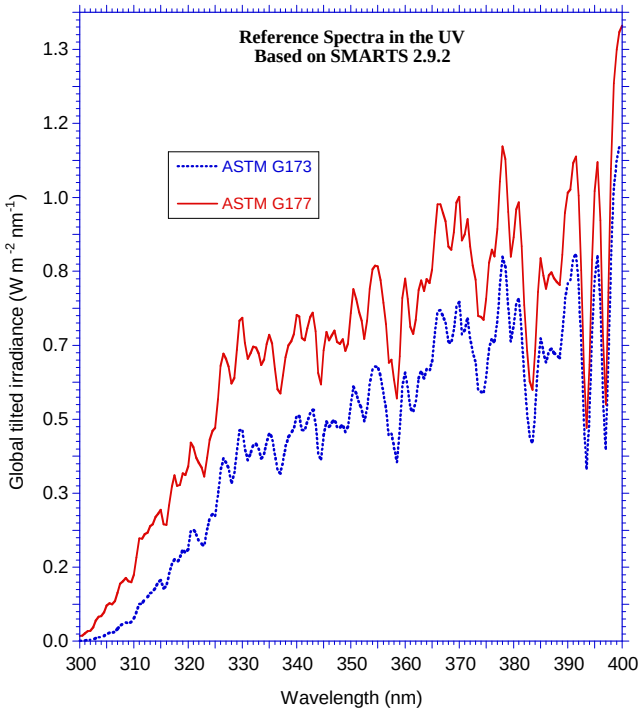

Fig. 2: *Comparison of global irradiance on a 37°-tilted sun-facing surface per ASTM G173-03 and G177-03 standards.*

Some Typical Applications

PV cells have widely different spectral responses depending on their technology. Because the rating of PV cells is obtained by reference to a single standard spectrum, their performance under a very different spectrum cannot be known a priori. It is therefore possible that, under real conditions, PV system A performs better than system B at clean-dry site X, but worse at tropical site Y. This can be analyzed beforehand by comparing typical spectra (that would be generated by SMARTS) for sites X and Y to that of the standard spectrum, and convoluting them with the spectral response of systems A and B. Wavelength-by-wavelength ratios can be easily obtained, from which a broadband mismatch factor can be calculated. This mismatch factor relates the performance of a solar cell under specific conditions to that under standard conditions. In other words, it relates the PV cell performance under

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any real-world condition to its standardized rating.

A similar procedure may be applied to the analysis of solar heat gains through spectrally-selective glazings in the built environment. Most fenestration devices (e.g., windows, glazed doors or skylights) sold in North America display a performance sticker approved by the National Fenestration Rating Council (NFRC, http://www.nfrc.org/). This sticker contains various pieces of information, including Solar Heat Gain Coefficient (SHGC) and Visible Transmittance (VT). These two coefficients are now obtained using a sophisticated methodology involving spectral calculations, and a single weighting function, which is currently the ASTM G159 global tilted spectrum. More than a decade ago, it has been shown that the variability in the solar spectrum caused non-negligible perturbations in SHGC. This in turn interferes with cooling load calculations, and finally in the design and cost of the air conditioning systems needed to counterbalance the cooling load in buildings.

Pic. 1: Daryl Myers operating a portable spectroradiometer at NREL's SRRL, April 2005.

To help engineers better design these air-conditioning systems, ASHRAE (http://www.ashrae.org/) has funded a research project to make spectral radiation information accessible to them in an easily assimilated way. SMARTS is the pivotal calculation tool in this project, one essential outcome of which being that scientists and practicing engineers will be able to select a major North American city and transparently obtain the necessary inputs to SMARTS that correspond to summer or winter design conditions (with respect to solar radiation) for the selected area. In support of this project, a paper will be presented at this year's ASES meeting, showing

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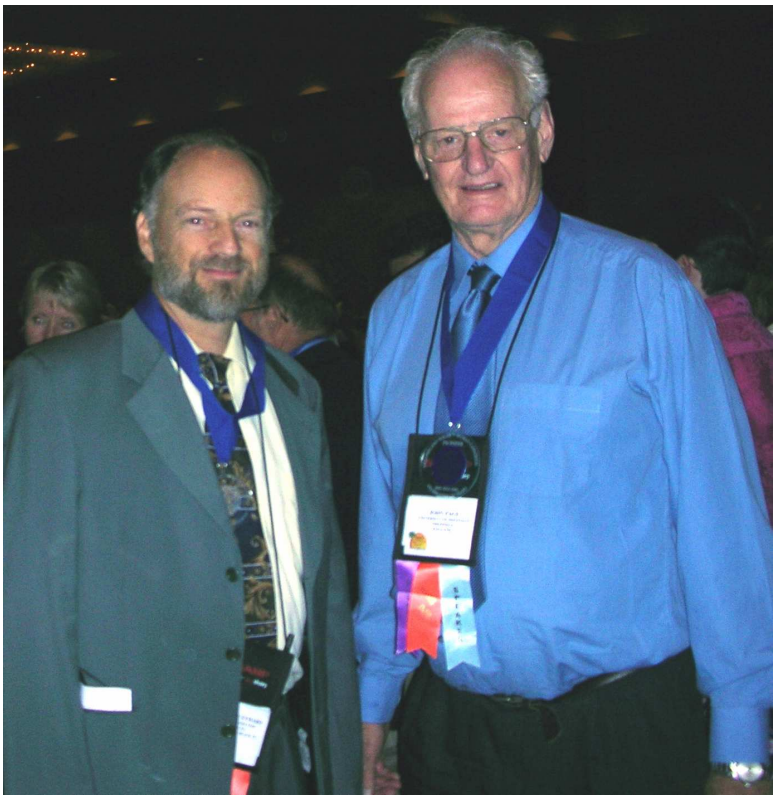
how spectral irradiance predictions on tilted or vertical surfaces can be validated by field measurements using portable spectroradiometers. Picture 1 shows such a specially requested measurement performed by Daryl Myers at NREL's Solar Radiation Research Laboratory (SRRL) in Golden, CO.

Workshops

A workshop on spectral radiation measurement and modeling was held at the ASES 2004 meeting in Portland. A follow-up workshop, which focused on the use of SMARTS, was offered at the ISES/ASES 2005 meeting in Orlando. Both workshops were well attended. Because of its international background, the 2005 workshop attracted participants from over the world. The presenters (this author and Daryl Myers) were honored by the presence of Emeritus Professor John Page, who for years has been supporting the use of SMARTS in various European research projects. Even though John Page officially retired from the University of Sheffield years ago, he is still active in the European solar radiation community. As a pioneer in the field, he also received well-deserved recognition by ISES: the Farrington Daniels Award in 1989. He was also one of the recipients of the Solar Pioneer Award at a moving ceremony that ISES organized during the 2005 conference. Picture 2 portrays him (with this author) during the ceremony.



Pic. 2: Chris Gueymard (left) and John Page (right) during the ISES Pioneer Award ceremony, 2005. (Photo courtesy Richard Perez)

Although no new general workshop is planned for the near future under the ASES banner, it is conceivable that a specially tailored event be organized for a targeted audience to cover specific applications, should the need surface.

NREL PREPARES TO RELEASE UPDATED NATIONAL SOLAR RADIATION DATA BASE

by Steve Wilcox

The National Renewable Energy Laboratory (NREL) plans to release an update to the National Solar Radiation Data Base (NSRDB) this summer. NREL undertook the project in collaboration with several other agencies, including the National Aeronautics and Space Administration (NASA), the National Climatic Data Center (NCDC), the Northeast Regional Climate Center (NRCC), the State University of New York at Albany (SUNYA), the University of Oregon, the University of Wisconsin, and the private firm Solar Consulting Services. The release in 1992 of the original 1961-1990 NSRDB provided solar resource assessment users a database of hourly solar and meteorological values for 30 years for 239 sites in the United States and its territories. The update – which will include a decade data set from 1991-2000 and five incremental annual data sets from 2001-2005 – includes over 800 stations with a complete period of record from 1991-2000 (called Class I stations). Almost all of the original 239 NSRDB stations are included in this list of stations. As with the original NSRDB, the update will contain predominantly modeled data.

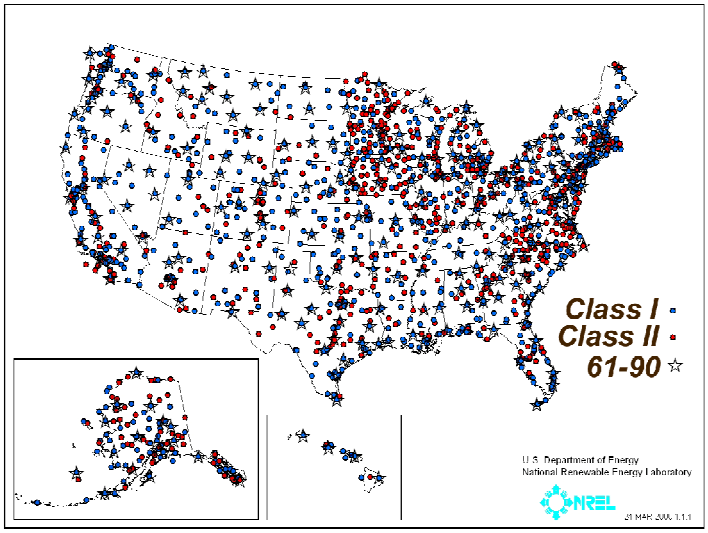


Fig. 1: Map of the stations in the updated National Solar Radiation Database. Starts indicate 61-90 NSRDB sites.

In addition to the Class I sites, the update includes about 500 Class II stations, which are so classified for lack of a complete period of record. While these stations aren't suitable for inclusion in Typical Meteorological Year (TMY) and other NSRDB spin-off products (to be generated at a later date), they are included because of their potential to provide solar resource data for applications not requiring a complete period of record.

As a major addition to the original NSRDB, the update features a high resolution hourly ten-kilometer gridded solar data set for 1998-2005. This data set derives from GOES satellite imagery using a model developed by a team headed by Dr. Richard Perez at SUNYA.

A major effort of the da-

NREL PREPARES TO RELEASE UPDATED NATIONAL SOLAR RADIATION DATA BASE

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tabase development was accommodating the loss of total and opaque cloud observations when the National Weather Service switched from human observations to Automated Surface Observation System (ASOS) data acquisition. These cloud measurements are a dominant input to the Meteorological Statistical (METSTAT) model used for the ground-based irradiance estimates. For the updated NSRDB, total and opaque cloud values were estimated using ASOS data and the NCDC Supplemental Cloud product (a satellite-based data set).

As with the original NSRDB, the updated data sets will be distributed by NCDC.

The project team has scheduled an NSRDB informational meeting at the upcoming ASES conference at the Adams Mark Hotel in Denver to discuss features, development, and distribution. The meeting will be held Wednesday July 12, 4:00 - 5:30 p.m. and will be open to all conference attendees.

Contact: Steve Wilcox (303-384-7785 or stephen_wilcox@nrel.gov)

Renewable Application Sessions at Solar 2006

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Physics

James M. Bing, New Energy Options, Inc

Monday 4:00—5:30

Solar Resources: Temporal and Spatial

Session Chair: Darryl Myers, National Renewable Energy Lab

The Impacts of Climate Changes in the Renewable Energy Resources in the Caribbean Region
M. Angeles and J. González, University of Puerto Rico-Mayagüez and D. Erickson III and J. Hernández, Oak Ridge National Laboratory

Uncertainty Calculations in Pyranometer Measurements and Applications
M. Kratzenberg,Federal University of Santa Catarina, BRAZIL; H. Beyer, University of Applied Science Magdeburg-Stendal, GERMANY and S. Colle and A. Albertazzi, Federal University of Santa Catarina, BRAZIL

Inter-comparison of Solar Resource Data Sets: NASA-SRB/SSE versus DLR-ISIS Global and Beam Irradiance
R. Meyer and S. Lohmann, DLR Institut für Physik der Atmosphäre, GERMANY; P. Stackhouse, NASA Langley Research Center and J. Mikovitz, W. Chandler and S. Gupta, Analytical Services and Materials, Inc.

Long-Term Variability of Global and Beam Irradiance in the Pacific Northwest
L. Riihimaki and F. Vignola, University of Oregon; S. Lohmann and R. Meyer, DLR Institut für Physik der Atmosphäre, GERMANY and R. Perez, ASRC, the University of New York at Albany

Deriving Long Term High Resolution Solar Irradiances from Low Resolution Archives via Microstructure Patterning
R. Perez and M. Kmiecik, ASRC, the University at Albany; S. Wilcox, National Renewable Energy Laboratory and P. Stackhouse, NASA Langley Research Center

Tuesday 10:30—Noon

PV Modeling

Session Chair: Craig Christensen, National Renewable Energy Lab

Ramifications of Installed NOCT Values
J. McCabe, Energy Ideas, LLC; B. Brooks, Brooks Engineering and J. Newmiller, BEW Engineering (A)
Development of a Digital Shade Analysis Tool for PV Siting
O. Bartholomy, B. Sloan and J. Bertolino, Sacramento Municipal Utility District

Recent Upgrades and Revisions to PVWATTS
B. Marion, M. Anderberg and P. Gray-Hann, National Renewable Energy Laboratory

A GIS-Based System for Per-

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formance Assessment of Solar Energy Systems over Large Geographical Regions
T. Huld, M. Šúri and E. Dunlop, European Commission, Joint Research Centre, ITALY

Renewable Energy Screening: Identifying and Prioritizing Solar Opportunities in Federal Facilities
A. Walker, D. Heimiller and A. Kandt, National Renewable Energy Lab and A. Sprunt-Crawley, US DOE

Poster Session II

Tuesday 12:30—1:30

New Renewable Energy Prototype Data Sets from NASA Satellites and Research
P. Stackhouse, Jr., NASA Langley Research Center; C. Whitlock, W. Chandler, J. Hoell and D. Westberg, Science Applications International Corporation and T. Zhang, Analytic Services and Materials

The Necessity and Economics of Solar Radiation Resource Assessment
D. Myers, National Renewable Energy Laboratory

Digital Camera Based Site Evaluation Tool
B. Marion, National Renewable Energy Laboratory

The Direct Solar Radiation Analytical Model and the Solar Planar Modules' Tilt Selection to Maximize the Annual Insolation of Their Surfaces
S. Kivalov, Renewable Energy Research and V. Evdokimov, D. Strebkov and E. Tver'yanovich, All-Russian Research Institute for Electrification of Agriculture, RUSSIA

SPECIAL SESSION

Wednesday 4:00—5:30

Announcement of the release of the updated National Solar Radiation Data Base.
Steve Wilcox, NREL

Information for these resource application sessions is from the preliminary schedule. Check the schedule for additional papers and for any changes in the program.