DOE Solar Energy Technologies Program Peer Review

Technical Track: CSP Resource Assessment

Project Name: Solar Resource Assessment

Principal Investigator: Dave Renné

Denver, Colorado

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This presentation does not contain any proprietary or confidential information.

Quality, Productivity, Accomplishment

- Experienced, veteran team
  - In-house expertise integrating science, engineering, analysis, scientific computing and GIS/visualization skills
  - World-class contractors and consultants (SUNY/A, U of OR)
  - Collaboration with experts throughout U.S. and world (IEA/SHC Task 36, WMO, NOAA, NCAR, NASA, UNEP/SWERA)
  - Broad professional service (ASES and ISES Boards, Solar Energy Journal Editors, professional committees and societies)

Team Members:

Dave Renné, Project Lead
Tom Stoffel, Group Manager
Stephen Wilcox
Ray George
Daryl Myers
Chris Helm
Mary Anderberg
Afshin Andreas
Pete Gotseff
Pamela Gray-Hann

Subcontractors/Consultants:

Richard Perez, SUNY/Albany
Frank Vignola, U of OR
Bernie Walter, Consultant
Chris Gueymard, Consultant

In Addition:

NREL's Scientific Computing Team
NREL's GIS and Visualization Team

Quality, Productivity, Accomplishment

- Major and planned accomplishments
  - Updated NSRDB and TMY solar data sets for the U.S. (1991-2005 completed in FY2008; annual updates to be implemented beginning in FY2009)
    - PV: ~$150K; CSP: ~$100K
  - Initiated in-house solar model development
    - PV: ~$150K; CSP: ~$200K; RSI: ~$100K
  - Evaluated solar forecasting requirements and methodologies
  - Initiated new forecasting efforts with SUNY/Albany
    - PV: $250K; CSP: ~200K
  - Initiated solar resource road mapping exercise
    - PV: ~$25K; CSP: ~$25K
  - Continued operating agent (OA) support to IEA/SHC Task 36 “Solar Resource Knowledge Management”
    - PV: ~$100K; CSP: ~$50K
  - Installed 4 SOLRMAP solar monitoring stations (CSP)
    - CSP: $310K
  - Support stakeholders through Web-based tools, workshops, presentations
    - PV: $75K; CSP: ~$65K
- FY 2009 Budget:
  - PV = $750K
  - CSP = $950K
  - RSI = $100K

Quality, Productivity, Accomplishment

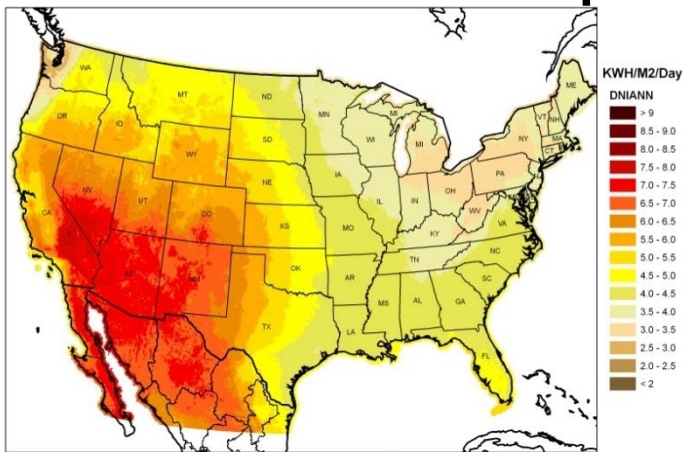
- Recent Key Accomplishments
  - Hosted CSP Solar Resource Data Users Workshop, October 2008
    - NREL to continue to provide climatologically-significant data and products
    - Accuracies and confidence limits to be clearly defined and identified
    - SOLRMAP a key step in providing “bankable” data
    - NREL to develop “Best Practices” manual
    - Conduct R&D that leads to further improvement of solar forecast models
  - Initiated road mapping exercise (December 2008)
  - Installed 4 SOLRMAP stations
  - Led 5 IEA/SHC Task 36 Experts Meetings since 2005; 6th Meeting in Spain in mid-March
  - Participated in CAISO Solar Forecasting Workshop (February 2009)
  - Several technical papers to be presented at Solar 2009, Buffalo, NY May 13-15
  - Broadened collaborative activities with grid integration studies (e.g. Hawaii, WWSIS)

Scientific/Technical Approach

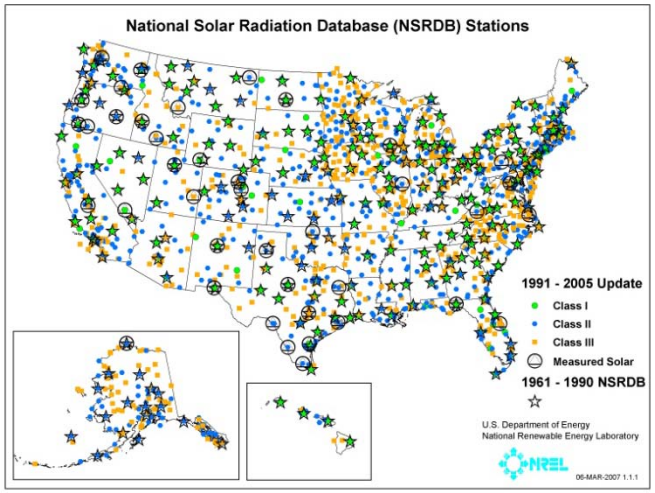
- National Solar Radiation Data Base Updates
  - Planned annual updates, using satellite data purchased from CPR, METSTAT model applied to surface observed weather data
  - Next update: 2006
  - Continuous improvement in satellite-derived model, input data sources, METSTAT model
  - Key “benchmark” data sets to support PV, CSP, grid-integration programs
  - Public-private sector roles identified
    - NREL produces “climatologically-significant” data sets to maintain continuity with historical data base
    - Private sector markets recent data (primarily satellite-derived) that have value to developers

Scientific/Technical Approach

- National Solar Radiation Data Base – 1991-2005 Update

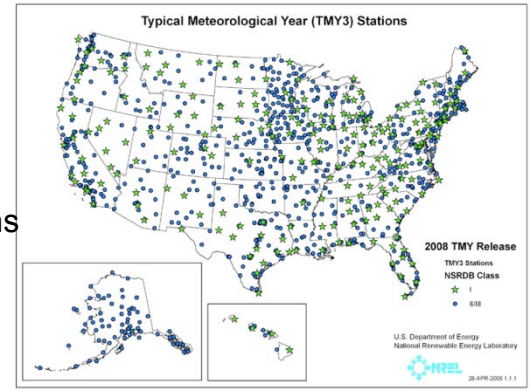


Gridded satellite data (SUNY/Albany)



Surface stations

TMY3 Stations



Data Access

Data Set	Distributor	URL
NSRDB solar and filled meteorological fields	NCDC	ftp://ftp.ncdc.noaa.gov/pub/data/noaa [No-cost access is domain-restricted to .mil, .gov, .edu, and .k12. A fee-access restriction applies to all other domains]
NSRDB solar and ISH meteorological fields (no data filling)	NCDC	[At the time of this writing, this data set is planned for a late 2007 release] http://cdo.ncdc.noaa.gov [No-cost access is domain-restricted to .mil, .gov, .edu, and .k12. A fee-access restriction applies to all other domains]
NSRDB solar fields; NO meteorological	NCDC	ftp://ftp.ncdc.noaa.gov/pub/data/nsrdb-solar (no fee)
SUNY 10-km gridded data	NCDC	ftp://ftp.ncdc.noaa.gov/pub/data/nsrdb-solar (no fee)
NSRDB statistical summaries	NCDC	ftp://ftp.ncdc.noaa.gov/pub/data/nsrdb-solar (no fee)
NSRDB research solar fields; NO meteorological	NREL	http://rredc.nrel.gov/solar/old_data/nsrdb/ 1991-2005 (no fee)

Scientific/Technical Approach

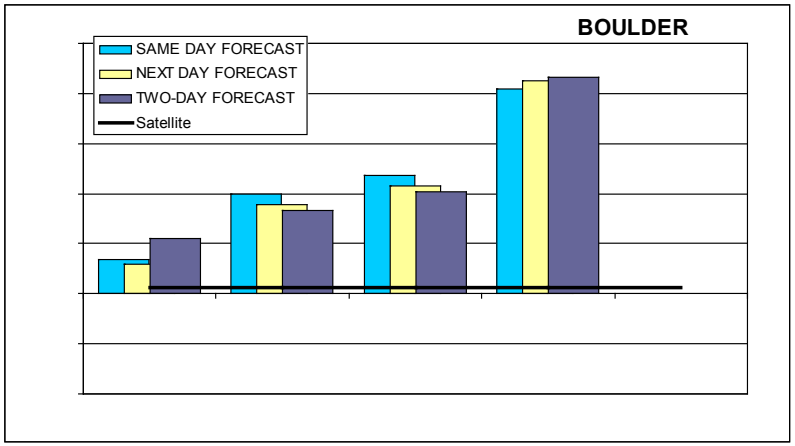
- Solar Resource Forecasting
  - Monitoring current R&D and commercial practices through IEA Task 36, participation in solar forecasting workshops, literature surveys, etc.
  - Initiating in-house and subcontracted activities
    - Forecast validation (as derived from GFS, ECMWF, downscaling schemes such as WRF)
    - Forecast model improvements
    - Testing of cloud motion vector schemes (SUNY/Albany)
    - Will NOT re-create specific forecasting schemes that are currently the domain of the private sector

Scientific/Technical Approach

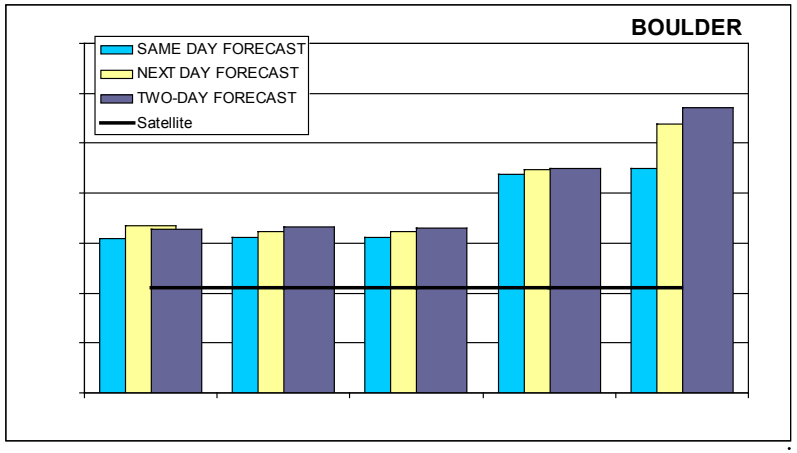
- Solar Resource Forecasting (cont'd)
  - Approaches
    - Cloud motion vectors (0-6-hour) using satellite and local (e.g. all-sky camera) observational systems
    - Dynamic modeling, neural networks (day to 3-day ahead)
    - Long-range forecasts (seasonal)
    - Interannual variability (derived from historical statistics)
  - Importance
    - Utility-scale grid-tied PV installations
      - Efficient dispatching
      - Load planning
    - CSP Operations
      - Load planning
      - Maintenance scheduling

Scientific/Technical Approach

Solar Resource Forecasting – Recent Results



Mean bias error (MBE) for various solar forecasting models compared with high-quality solar measurements in Boulder, CO



Root mean square error (RMSE) for various solar forecasting models
Compared with high-quality solar measurements in Boulder, CO

Location of solar monitoring stations in U.S. where several forecasting schemes are being tested by Task 36 participants

Scientific/Technical Approach

- Solar Resource Modeling
  - Adapting well-established satellite-derived semi-empirical models, such as SUNY/Albany
  - Working with highly-qualified consultants and in-house scientific computing staff
  - Established routine access to satellite imagery
  - Assigned teams to develop input data sets (e.g. AOD, snow cover) and identify model limitations (temporal and spatial resolutions)
  - Strategic hire(s) pending
  - Goal: Provide “gold standard” data sets benchmarked with high-quality ground data
  - Importance: Supports in-house R&D; enables access by private data providers with most up-to-date capabilities

Scientific/Technical Approach

Composite of GOES-E and GOES-W images showing coverage available to NREL

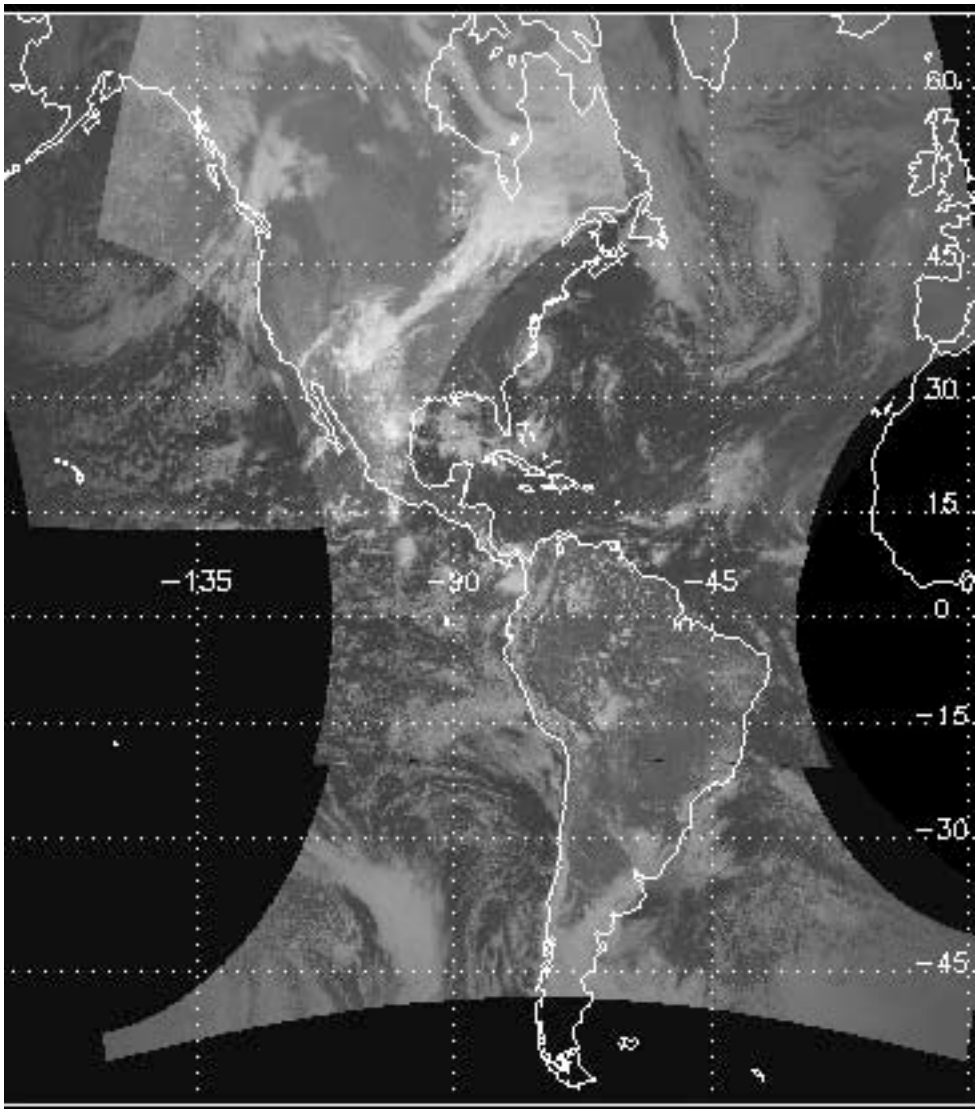


Image provided by Bernard Walter Consulting

Scientific/Technical Approach

SOLRMAP (Solar Resource and Meteorological Assessment Project)

- High-quality ground-based solar monitoring stations (12, or more if enhanced funding becomes available)
- Installed in cooperation with utilities and developers using NREL CRADAs through the CSP Program
- Supports development activities of stakeholders; provides NREL with critical research data sets
- Stations are operated by the utility; NREL supervises installation, oversees data quality assessment, makes data available via Web (public or secured)
- Four stations currently installed in AZ, CO

Relevance/Impact of Research

Impact

- Access to high-quality data sets facilitates cost-effective system planning and design
- Improved solar forecasting and sub-hourly data analysis supports more effective solar dispatching and grid operations
- In-house modeling capability will establish means to define uncertainty of commercial and government-derived data sets, and define research goals to improve publicly-accessible data quality
- Operating agent support to Task 36 allows for collaborative engagement of international research community to help guide and improve U.S. research activities and improve access to global data sets
- Dissemination and outreach of data and analysis products raises U.S. industry market awareness of the potential for solar energy development

Future Directions

Implementation of Solar Resource Road Map

- Maintain historical databases through annual NSRDB updates
- Develop modeling capability that serves as R&D platform and a means to support private data providers
- Develop enhanced data products targeted to specific analytical and industry needs
  - Microscale analyses
  - Extrapolation of short-term data sets
  - High-resolution time scale
  - Cross-correlation analyses
  - Best practices manual
- Provide site-specific best estimates: SOLRMAP combined with long-term data sets
- Establish lead role in testing, evaluating, and validating solar forecast schemes
  - 0-6 hour-ahead
  - 1-3 day-ahead
  - Seasonal, interannual
- Maintain and enhance solar evaluation tools (e.g. PVWatts, Solar Power Prospector)