How to Utilize NASA Resources for Energy Efficiency and Renewable Energy Applications

Collaboration between NASA POWER for NASA ARSET

June 22, 2021
What are POWER GIS Web Services?

What is POWER’s Purpose?

• POWER stands for “Prediction of Worldwide Energy Resources” project funded by NASA to help facilitate the usage of NASA Earth observations, analysis, and modeling to answer key societal questions.

• POWER aims to improve the nation’s public/private capability for integrating environmental data from NASA Earth observations and research, particularly surface solar irradiance, to support increased:
  – renewable energy development,
  – building energy efficiency and sustainability, and
  – agroclimatology applications.

Photo Credits: nrdc.org, solvay.com, harvestreturns.com
How is the POWER GIS Web Services Improved?

<table>
<thead>
<tr>
<th>Data Providers Interaction and Planning</th>
<th>User Interaction/Partnerships/Requirements Capture</th>
<th>Public Discovery &amp; Data Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Processing, Customization and Integrity</td>
<td><img src="image" alt="POWER Website" /></td>
<td><img src="image" alt="APIs" /></td>
</tr>
<tr>
<td><img src="image" alt="CERES" /></td>
<td><img src="image" alt="User Interface" /></td>
<td><img src="image" alt="Web Mapping Services" /></td>
</tr>
<tr>
<td><img src="image" alt="FLASHFlux" /></td>
<td><img src="image" alt="User Interface" /></td>
<td><img src="image" alt="Data Access Viewer" /></td>
</tr>
<tr>
<td><img src="image" alt="NASA-GEOWEX" /></td>
<td><img src="image" alt="User Interface" /></td>
<td><img src="image" alt="Available on Beta!" /></td>
</tr>
<tr>
<td><img src="image" alt="GMAO" /></td>
<td><img src="image" alt="User Interface" /></td>
<td></td>
</tr>
</tbody>
</table>

OPeNDAP® is a registered trademark of the Advanced Software for Remote Data Retrieval.
What is POWER’s approach to building community relationships?

Collaboration and Partnership Building: Governmental and Professional Organizations

  - Historically NASA supplied data where there were no surface observations
- RETScreen® (Natural Resources Canada)
  - Integration of the POWER Data into the RETScreen® software enabling world-wide access to data without the need for a surface site to conduct analysis.
- ASHRAE© (formerly American Society of Heating, Refrigeration and Air-Conditioning Engineers):
  - Demonstrate usefulness of NASA EO
  - Enable public access globally of the ASHRAE climatic design conditions report using POWER Data.

SWERA was early collaboration between NREL, USGS and NASA (https://openei.org/apps/SWERA//).
How often is POWER being used?

POWER Web Services Portal collects a variety of information to understand data requests and changes of the user base while maintaining free and anonymous access.

- *track overall usage by collecting key measures of data requests and unique users (i.e., metrics)*
- *Also, track orders by data set source, user community and parameter.*

### Monthly Cumulative - Metrics Information

<table>
<thead>
<tr>
<th>Requests</th>
<th>Unique Users (IP Based)</th>
<th>Data Volume (GB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>06/01/2019 to Present</td>
<td>06/01/2019 to Present</td>
<td>06/01/2019 to Present</td>
</tr>
<tr>
<td>148,997,987</td>
<td>276,425</td>
<td>16,003 GB</td>
</tr>
</tbody>
</table>

### Cumulative - Geospatial Services

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1999/06/01 to 2018/04/30</td>
<td>2018/05/01 to Present</td>
</tr>
<tr>
<td>Requests</td>
<td>35,988,533</td>
<td>180,052,616</td>
</tr>
<tr>
<td>Data Volume (GB)</td>
<td>3,612 GB</td>
<td>22,004 GB</td>
</tr>
</tbody>
</table>
What Sorts of Data Help Enhance POWER’s Utility?

Time Averaged versus Time Series

- Some users require statistics from long-term averaged data parameters
  - Useful for feasibility and engineering studies for large numbers of renewable energy projects
  - POWER beta now allows users to choose years for long-term averages
- Some users require time series data products
  - Useful for modeling energy systems with observed variability
  - Useful for monitoring building energy efficiency performance
  - POWER beta now allows up to hourly averaged data products but also features daily, monthly, annual time series statistics
Using the Climatological Averages

POWER’s Value Added Products Enhance Usage

Base and Derived Parameters for POWER GIS
All parameters are available globally at the source data resolution.

<table>
<thead>
<tr>
<th>Climatological Base Parameter</th>
<th>Climatological Value Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>• All-Sky &amp; Clear-Sky Surface Solar Insolation on Horizontal Surface</td>
<td>• Solar geometry, Surface albedo, Direct Normal, Diffuse,</td>
</tr>
<tr>
<td>• Surface Reflected Solar Flux</td>
<td>• Tilted surface solar parameters including optimal angle/irradiance computations</td>
</tr>
<tr>
<td>• All Sky Downward Longwave Radiative Flux</td>
<td>• 3-hourly solar fluxes and cloud parameters,</td>
</tr>
<tr>
<td>• Top-Of-Atmosphere Insolation</td>
<td>• No-sun Days (Black-sky days), min insolation over day periods for battery backup</td>
</tr>
<tr>
<td>• Air Temperature at 2 m, 10 m</td>
<td>• Heating/Cooling Degree Days (for 0°C, 10°C, 18.3°C standards)</td>
</tr>
<tr>
<td>• Specific Humidity at 2 m, 10 m</td>
<td>• Skin Temperature max/min/range, Frost Days,</td>
</tr>
<tr>
<td>• Surface Dewpoint at 2 m</td>
<td>• Total Column Precipitable Water</td>
</tr>
<tr>
<td>• Surface Pressure</td>
<td>• ASHRAE® Building Climate Thermal &amp; Moisture zones</td>
</tr>
<tr>
<td>• Surface Skin Temperature</td>
<td>• Wind Roses by Energy classes</td>
</tr>
<tr>
<td>• U, V, Wind Speed, &amp; Wind Direction at 2 m, 10 m, and 50 m</td>
<td></td>
</tr>
</tbody>
</table>
What is Equator Tilted Surface Irradiance?

- Solar panel surface tilted toward the equator at an angle equivalent to location latitude (a first estimate for a solar panel)
- Currently uses an industry standard parameterization for climatological average solar irradiance (improved in new version)
- Tilted irradiance provided for a set of angles
- Output tables including an optimal tilt angle and corresponding irradiance
Assessment of Equator Tilted Surface Irradiance

Assessing tilted surface irradiance is very hard due to scarce measurements. Here we obtained some tilted surface measurements and also devised a technique to estimate using standard measurements giving < 3% bias and 14% RMS at monthly average.

Monthly Validation against Titled surface irradiance from University of Oregon Site

Information found in the POWER methodology documentation

NASA’s Applied Remote Sensing Training Program

BSRN = Baseline Surface Radiation Network
SSE = Surface Solar Energy
How can long-term solar averages be used?

Evaluation of an African Community Solar Panel System

• A community solar power project in a remote village in West Africa appeared to be working poorly.

• A solar consultant investigated using insolation data from the “POWER Single Point Data Access” application on POWER’s “Data-Access-Viewer”. Sample data:

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
<th>ANN</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNR</td>
<td>6.13</td>
<td>5.88</td>
<td>5.04</td>
<td>4.29</td>
<td>4.12</td>
<td>3.54</td>
<td>2.97</td>
<td>2.84</td>
<td>3.25</td>
<td>4.09</td>
<td>4.65</td>
<td>5.67</td>
<td>4.37</td>
</tr>
<tr>
<td>DNR_MAX</td>
<td>7.53</td>
<td>7.42</td>
<td>5.7</td>
<td>4.78</td>
<td>4.68</td>
<td>4.3</td>
<td>4.04</td>
<td>3.56</td>
<td>3.99</td>
<td>4.7</td>
<td>5.05</td>
<td>7.13</td>
<td>5.24</td>
</tr>
<tr>
<td>DNR_MIN</td>
<td>4.97</td>
<td>4.81</td>
<td>4.42</td>
<td>3.85</td>
<td>3.47</td>
<td>2.76</td>
<td>2.3</td>
<td>2.27</td>
<td>2.59</td>
<td>3.57</td>
<td>3.88</td>
<td>4.51</td>
<td>3.62</td>
</tr>
</tbody>
</table>

• Going to the “POWER Layer List” application that features image services, the consultant was also able to do a quick visual survey of solar energy potential in the whole region.
How can long-term solar averages be used?

Evaluation of an African Community Solar Panel System

- The long-term annual averaged daytime cloud amount >60%; with 9 of 12 climatological month averaged > 50%
- Despite the tropical location, frequent cloud cover significantly lowered the Direct Normal Radiation (DNR) which is needed for the efficient operation of photovoltaic modules.
- POWER’s DNR data revealed that the solar array was actually performing up to specifications, though not up to expectations.
- Local management made the necessary adjustments to power usage and billing and were able to move forward better informed.
How can solar irradiance parameters be used?

DEVELOP Satellite Beach Energy (Solar Roofs)

• The City of Satellite Beach, Florida, has committed to supplying 100% of its energy use from renewable energy, primarily solar, by the year 2050.

• The team estimated rooftop solar power potential using a high-resolution Light Detection and Ranging (LiDAR) dataset and the NASA Prediction of Worldwide Energy Resources (POWER) dataset to assist Satellite Beach in reaching their solar renewable energy goals.
How can wind parameters be used?

**Optimal wind farm placement**

- On land wind technology now has a comparable levelized cost of electricity to fossil fuels
- Wind speeds can be used along with terrain maps to find the best placement
- Temporal variation can further refine that placement

*Figure 5: from Bosch et al., 2017 showing seasonal variation of average capacity factor in China*
Maritime Usage of POWER Climatological and Time Series Data

Autonomous energy systems needed for remote marine structures

- To support renewable energy for remote navigation aids, IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities) publishes a solar and storage system design guide and sizing tool—which relies on NASA POWER for the core inputs.

- POWER global data and specialized parameters integrate into IALA’s tool in ways that other irradiance-only datasets cannot.

- Sample critical Inputs are:
  - Daily global all-sky insolation
  - Long-term statistics:
    - “black-sky days” parameter informs battery backup decisions using daily irradiance variability
    - tilted irradiance estimates including optimal tilt angle estimates

(Courtesy ICF POWER Use Case Report, 2021)
**How Can Near-Real Time Parameters by used?**

**Solar Panel Installation Monitoring**

- User manages 50 solar panel sites producing 5.3 MW of power.
- Reads POWER low latency and sensors to help monitor performance.
- Noted divergence > 5% with POWER surface irradiance.
- Used CERES SYN1Deg (new POWER Beta) and EBAF (not shown) to evaluate for trend; none found.
- After several additional months divergence reached 50%
- User concluded sensor was bad.
How can solar irradiance parameters be used?

Solar Photovoltaic Panel Array Monitoring

• A Customer First Renewables’ consultant obtains POWER’s near-real time solar irradiance from CERES FLASHFlux (~6-7 days).

• These data are compared to the energy produced from five solar photovoltaic (PV) panel array fields monitored in North Carolina, US.

• The variability of solar field electrical output is compared to day-to-day solar irradiance values to assess performance and identify potential system problems.
The RETScreen® Partnership

- The POWER project has had a partnership with RETScreen® for over 20 years where POWER provides global data as:
  - Climatological averages that are embedded in the software
  - Near-real time obtained via a direct connection to POWER

- World’s leading clean energy decision making software
  - Benchmark, feasibility, performance, and portfolio analysis
  - Energy efficiency, heating and cooling, power generation and cogeneration
  - 36 languages covering 2/3 of world’s population
  - 700,000+ registered users
RETScreen®’s Integration of POWER Data

- A RETScreen® Expert “climate data” input screen is shown; if surface measurements are unavailable RETScreen uses POWER provided estimates
- Parameters include long-term averages by month of multiple parameters such as (embedded):
  - Surface temperatures
  - Precipitation
  - Winds
  - Solar Irradiance
- Similar parameters for energy monitoring applications requiring the near-real time data stream directly accessed through POWER’s API
RETScreen® and POWER Applications: Solar Technologies

Solar Wall – Wicked Joe Coffee

• Wicked Joe is a family-owned coffee company that wanted to use sustainable business practices
• Their facility was 20,000 sq ft (1858 sq m) and the company wanted to save heating costs
• They assessed renewable technologies to meet their needs; considering their Maine location in the Northeastern US
• The builders utilized RETScreen® and POWER data to determined that a glazed solar wall would capture 40% more heat.
• The company reports cost savings of approximately $10,000 per year.

See more at Space for US
RETScreen® and POWER Applications: Solar Power Plant

Should this solar power plant pay to have snow cleaned off their panels in winter?

Ottawa Renewable Energy Cooperative
293 kW Solar Power Plant Facility (Ottawa, Canada)

Monthly electrical output compared to monthly averaged solar irradiance (corrected with tilt parameterization) from CERES FLASHFlux via POWER.

Control chart (Baseline)

Snow problems!

Energy not produced!

Legend:
- Electricity - Actual
- Daily solar radiation - tilted (Fixed - 18.0° - 0.0°)
- Electricity - Estimated

Ottawa Renewable Energy Cooperative
293 kW Solar Power Plant Facility (Ottawa, Canada)
RETScreen® and POWER Applications: NASA LaRC Solar Panel

Four building energy assessments working with center energy management officials and RETScreen.

Steady state RETScreen regression models provide for energy performance analysis (NASA TMs available).

Net Savings 160 MWh (2/10–3/13)

Solar Panel Electrical Output (kWh)
RETScreen® and POWER Applications: NASA Building Energy

Building Energy Usage Monitoring: How much energy would have been used if all buildings were at normal capacity?

• NASA Langley’s Center Operations uses data from POWER and RETScreen to monitor energy usage for the entire center relative to weather and sunlight conditions.

• These are used to make an accurate estimate of the electrical energy not used during the 2019 Furlough by normalizing to weather conditions.

• NASA’s Office of Infrastructure is using RETScreen® and POWER NASA-wide to help assess building energy efficiency.
RETScreen® /POWER Applied Science Benefits the U.S.

• **Michigan**: University of Michigan uses RETScreen to monitor building energy efficiency and greenhouse gas emission ([UMich Link](#)). (uses POWER low latency data products)

• **Alaska**: U.S. Department of Agriculture Analyzes Wood Heating in Alaska with RETScreen ([AL Link](#)) (uses POWER daily long-term time series data product streams)

• **Massachusetts and Minnesota**: RETScreen used to developed renewable energy heating and cooling scenarios for policy incentive programs including solar hot water heating, biomass heat and advanced heat pump technologies ([MA link](#) & [Mn link](#)). (uses POWER climatology data).

• **Hawaii**: Department of Education implementing program to use RETScreen at all education buildings/schools (uses POWER low latency data products)

• **Wisconsin**: RETScreen is used extensively for the State’s Focus on Energy solar hot water incentive program for businesses. Also, using RETScreen potential projects are evaluated for savings and educational training and feasibility analysis are conducted ([WI link 1](#) & [WI link 2](#)) (uses POWER/SSE climatology data from GEWEX SRB, CERES, GMAO).
RETScreen®/POWER Applied Science Benefits the World

- **Canada/US:** Renewable energy engineers use daily solar irradiance to assess performance of multiple solar systems for clients of RETScreen® users in Ottawa region (e.g., others include MIT, Lockheed Martin, Corning, Johnson Controls)

- **Canada:** 3M Company manages 200+ facilities using RETScreen® and POWER low latency data: “The NASA datasets we use are critical to our energy analysis since they are used as major variables that predict our energy use.”

- **Spain:** Solar geometry and Solar Noon and Daylight Hours to design solar streetlights. – Pilar Pérez Oliván, Asesora Luminotécnica, Navarra

- **Peru:** Provider of solar systems in Peru and uses the POWER data to check amount of sun at a specific point. – Chavier E. Solano Isaya, Product Manager, Energía Solar y Automatización

- **Argentina:** Sizing and Pointing of Solar Panels in the new POWER data portal. Área Técnica, Goodenergy, Buenos Aires

- **Belgium:** “We’ve been using the NASA database for Nokia’s Renewable Energy solutions dimensioning.” – Nokia, Antwerpen
What are key parameters for building energy efficiency?

- Critical parameter for building systems is the heating and cooling degree days (HDD/CDD)
- POWER uses MERRA-2 to define long-term HDD/CDD

**Heating Degree Days:**

$$HDD = (T_{base} - <T_i>)^+$$

$$T_{base} = 18.3^\circ C (65^\circ F)$$

**Cooling Degree Days:**

$$CDD = (<T_i> - T_{base})^+$$

$$T_{base} = 10^\circ C (50^\circ F)$$

+ Positive definite: negative values are not included in sum
Global Validation of MERRA-2 Heating Degree Days
1981-2014, every 3rd year

Parameters Shown:
MERRA: T2MX, T2MN
MERRA2 O.P.: T2MX, T2MN
MERRA N.P.: T2MMAX, T2MMIN

\[ y = 1.0033x + 9.4770 \]
\[ R^2 = 0.9573 \]
\[ Bias = 0.3023 \]
\[ RMSE = 57.8983 \]
Global Validation of MERRA-2 Cooling Degree Days
1981-2014, every 3rd year

Parameters Shown
MERRA: T2MX, T2MN
MERRA2 O.P.: T2MX, T2MN
MERRA2 N.P.: T2MMAX, T2MMIN

y = 0.9811x - 2.2773
R^2 = 0.9890
Bias = -5.4441
RMSE = 33.4851

grid resolution 1/2 x 1/2 degree

NASA’s Applied Remote Sensing Training Program
ASHRAE® and POWER: Building Climate Zone Definitions

- Climatological annual HDD/CDD are used by ASHRAE to define Building Climate Zones
- Dry/humid/marine zones are determined using monthly and annual precipitation using MERRA-2
- Used by government officials to determine building code standards in US and around the world
- POWER provides maps/data for long-term building climate zones and variability

<table>
<thead>
<tr>
<th>Thermal Zone</th>
<th>Name</th>
<th>I-P Units</th>
<th>SI Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Extremely Hot – Humid (OA), Dry (OB)</td>
<td>10,800 &lt; CDD50°F</td>
<td>6000 &lt; CDD10°C</td>
</tr>
<tr>
<td>1</td>
<td>Very Hot – Humid (1A), Dry (1B)</td>
<td>9000 &lt; CDD50°F ≤ 10,800</td>
<td>5000 &lt; CDD10°C ≤ 6000</td>
</tr>
<tr>
<td>2</td>
<td>Hot – Humid (2A), Dry (2B)</td>
<td>6300 &lt; CDD50°F ≤ 9000</td>
<td>3500 &lt; CDD10°C ≤ 5000</td>
</tr>
<tr>
<td>3A and 3B</td>
<td>Warm – Humid (3A), Dry (3B)</td>
<td>4500 &lt; CDD50°F ≤ 6300 AND HDD65°F ≤ 3600</td>
<td>2500 &lt; CDD10°C ≤ 3500 AND HDD18°C ≤ 2000</td>
</tr>
<tr>
<td>3C</td>
<td>Warm – Marine (3C)</td>
<td>CDD50°F ≤ 4500 AND HDD65°F ≤ 3600</td>
<td>CDD10°C ≤ 2500 AND HDD18°C ≤ 2000</td>
</tr>
<tr>
<td>4A and 4B</td>
<td>Mixed – Humid (4A), Dry (4B)</td>
<td>2700 &lt; CDD50°F ≤ 6300 AND 3600 &lt; HDD65°F ≤ 5400</td>
<td>1500 &lt; CDD10°C ≤ 3500 AND 2000 &lt; HDD18°C ≤ 3000</td>
</tr>
<tr>
<td>4C</td>
<td>Mixed – Marine</td>
<td>CDD50°F ≤ 2700 AND 3600 &lt; HDD65°F ≤ 5400</td>
<td>CDD10°C ≤ 1500 AND 2000 &lt; HDD18°C ≤ 3000</td>
</tr>
<tr>
<td>5A and 5B</td>
<td>Cool– Humid (5A), Dry (5B)</td>
<td>1800 &lt; CDD50°F ≤ 6300 AND 5400 &lt; HDD65°F ≤ 7200</td>
<td>1000 &lt; CDD10°C ≤ 3500 AND 3000 &lt; HDD18°C ≤ 4000</td>
</tr>
<tr>
<td>5C</td>
<td>Cool – Marine</td>
<td>CDD50°F ≤ 1800 AND 5400 &lt; HDD65°F ≤ 7200</td>
<td>CDD10°C ≤ 1000 AND 3000 &lt; HDD18°C ≤ 4000</td>
</tr>
<tr>
<td>6A and 6B</td>
<td>Cold – Humid (6A), Dry (6B)</td>
<td>7200 &lt; HDD65°F ≤ 9000</td>
<td>4000 &lt; HDD18°C ≤ 5000</td>
</tr>
<tr>
<td>7</td>
<td>Very Cold (7)</td>
<td>9000 &lt; HDD65°F ≤ 12600</td>
<td>5000 &lt; HDD18°C ≤ 7000</td>
</tr>
<tr>
<td>8</td>
<td>Subarctic/Arctic (8)</td>
<td>12600 &lt; HDD65°F</td>
<td>7000 &lt; HDD18°C</td>
</tr>
</tbody>
</table>

The criteria for dry and humid are similar but not identical to those enumerated in Table 2B above.
Illustrating Climate Variability

- Using MERRA-2, POWER creates ASHRAE Building Climate Zone maps for the world.
  - Demonstrated to ASHRAE which subsequently used MERRA-2 for Quadrennial Handbooks.

- Also, created “rolling” climate zones from 4-year means to illustrate the changes in time from 1984 through 2019.
  - POWER Beta uses a Custom Zones API endpoint to create these maps.
  - Also, developed a series of python tools to convert to time-enabled the zones as ShapeFiles, Image Services, Feature Services, and GeoTIFFs, and Videos.
Climate Design Conditions Report

• New (and still being finalized), this report provides statistical meteorological and solar information important the sizing of various building systems such as heating and air conditioning

• ASHRAE provides this report for specific surface sites

• POWER GIS Web Services (beta) allows estimates anywhere in the world for a customized time period and location through the DAV ordering tool

• The long-term statistics utilize hourly values of temperature, humidity, wind, precipitation and solar parameters

• Statistics include percentile values as measure of extremes, conditional probabilities and long-term average values by annual and month
ASHRAE® and POWER: Custom Formats

Industry Standard EPW Format

• New in POWER GIS (beta) is the hourly EPW (EnergyPlus Weather) format:
  – Developed for hourly modeling on building systems
  – Used explicitly as input for the EnergyPlus software and many other similar tools

• Available through DAV under “Sustainable Buildings” group
  – Available for user specified location
  – From Jan 1, 2001 to Dec 31, 2019

• EPW contains numerous parameters including temperature, humidity, solar irradiance, solar illuminance, cloudiness, etc. (18 now; +6 later)

• EPW formats in two options: raw and CSV compatible.
POWER Geospatial Data Services

ArcGIS® Image and Feature Services allow users to efficiently interact with the POWER data in GIS applications.

- Allows for direct connection to data services in GIS desktop and web-based applications
- Provides Open Geospatial Consortium (OGC©) compliant services.
- Availability in multiple data portals NASA ArcGIS® Online, ASDC, and the Esri® Living Atlas

Hyperlink: [NASA AGOL - POWER](#)
The POWER Project

Provides solar and meteorological data sets from NASA research for support of renewable energy, building energy efficiency and agricultural needs.

Supported by NASA Earth Science’s [Applied Sciences Program](http://appliedsciences.nasa.gov)

POWER’s Enhanced Features
- Enhanced web-based POWER Docs pages
  - Data Methodology
  - Data Services Documentation
  - Data Access Tutorials

Multiple Data Access Options
POWER: Tools and Analytics

Story Map Evaluating Biases

• Key Features:
  – Allow users to navigate through a spatially enabled presentation enhanced with multi-media, narratives, and interactive GIS content
  – Provides a thorough overview, allowing users to develop their own conclusions from the underlying data.
  – Available on NASA AGOL, alleviating the need for users to have additional software

Hyperlink: Evaluating Biases
POWER Analysis – Bias Mapping

- The spatially enabled bias data then is used to create maps and conduct spatial analysis
- Have developed and released an example StoryMap® used to identify areas of regional bias
- This procedure will be used to validate the next version of the POWER Data Archive where the bias data will be hosted as web maps and standard text-based reports.
- The official bias information is in the POWER Methodology documentation hosted on the POWER Website.
Analytics with Jupyter Notebooks

• **Key Features:**
  – The POWER project has some Jupyter® notebooks currently available to conduct climate anomalies detection
  – Allow users to interact with the POWER API in a Jupyter® Notebook without the need for additional software.
  – Provides step by step instructions on how to use the new data services and tools
• Presented at the ASDC Data Presentation for 2020 DEVELOP Fellow Class on April 22nd, 2020

Hyperlink: [NASA POWER API Access](#)
What Have We Learned?

NASA Earth Observations (EO) data products through POWER are used to address energy related data needs.

• The POWER GIS Web Services provides parameters that have been developed in collaboration with:
  – NASA science projects: CERES, GMAO
  – renewable energy and energy efficiency engineers and researchers
  – organizations such as DOE/NREL and ASHRAE
  – partnerships with decision support providers such as NRCan RETScreen®

• Parameters provided are long-term averages and time series available from daily to annual
  – the next version (currently in beta) to include hourly parameters from January 2001

• Long-term averaged products include “value added” products like tilted solar irradiance and “black sky days” to better enable decisions in solar panel configuration and battery backup systems

• Multiple applications were demonstrated through including:
  – solar panel technologies and configurations,
  – solar monitoring, and
  – building energy performance monitoring.

• ASHRAE Building Climate Zones including a depiction of their variability show the value of geospatial services and analytic capabilities possible using GIS and other analytic tools

• The upcoming new version of POWER GIS Web Services is under continual development and will enable new applications.

• NASA research and community feedback will lead to continual improvement and development
Thank You!

Find us at: https://power.larc.nasa.gov/
Email us at: larc-power-project@mail.nasa.gov
How do you access POWER data?

- POWER provides an integrated services suite to efficiently access environmental data, pre-computed analysis reports for management of energy production, and monitoring energy efficiently systems, as source data for modeling software.

- The POWER data can be accessed form the:
  - Application Programming Interface (API)
  - Data Access Viewer (DAV)
  - Geospatial Services

![Multiple Data Access Options](image-url)