National Aeronautics and Space Administration

NASA

NASA POWER : GLOBAL SOLAR INSOLATION, METEOROLOGICAL PARAMETER DATA, AND WEB SERVICES TO SUPPORT SUSTAINABLE BUILDING DESIGN AND OPERATIONS

The Prediction Of Worldwide Energy Resources (POWER) Project, a NASA Earth Action Program Project

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- Taiping Zhang, Colleen Mikovitz, Bradley Hegyi, & Neha Khadka – Analytical Mechanics Associates (AMA)

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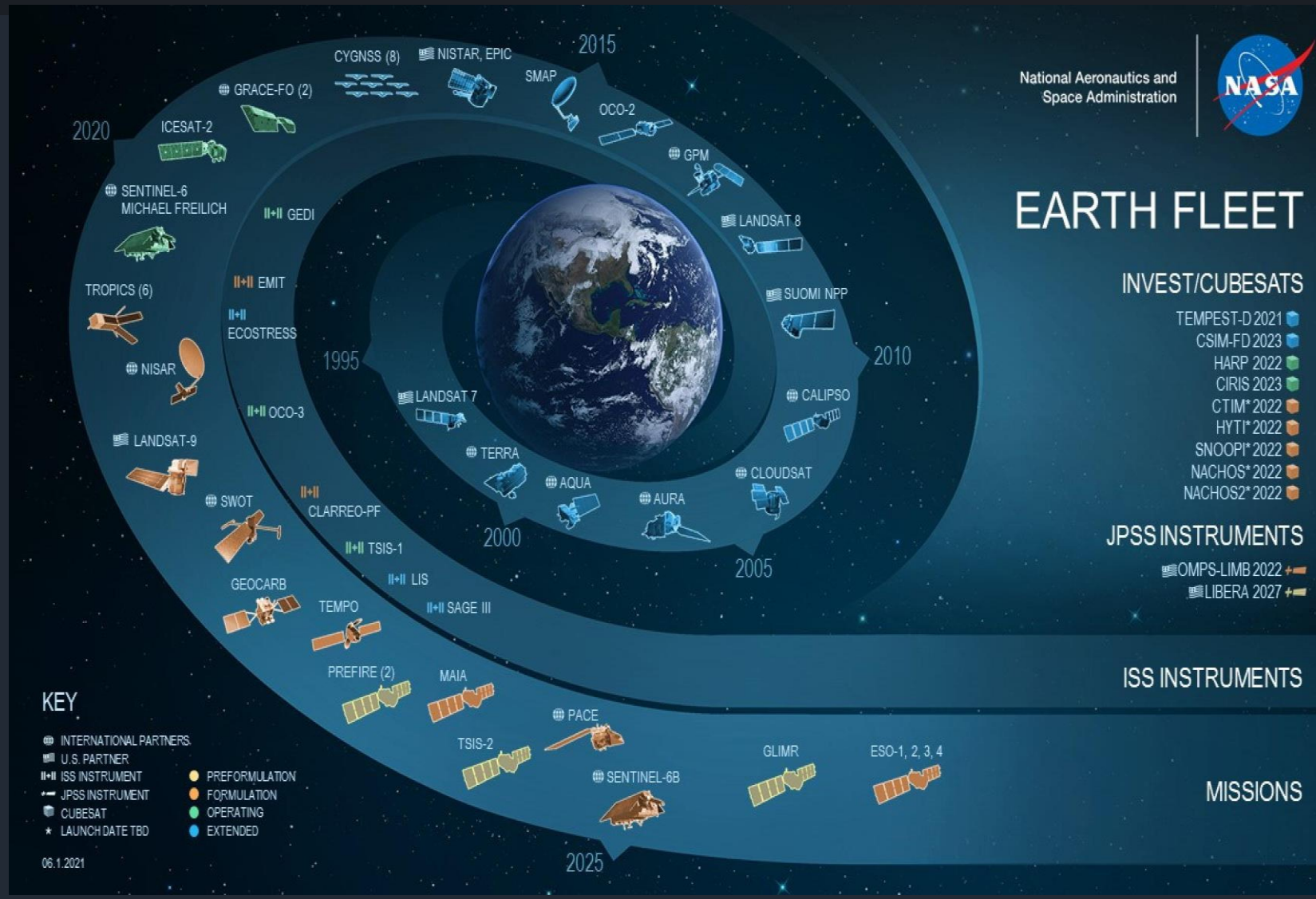
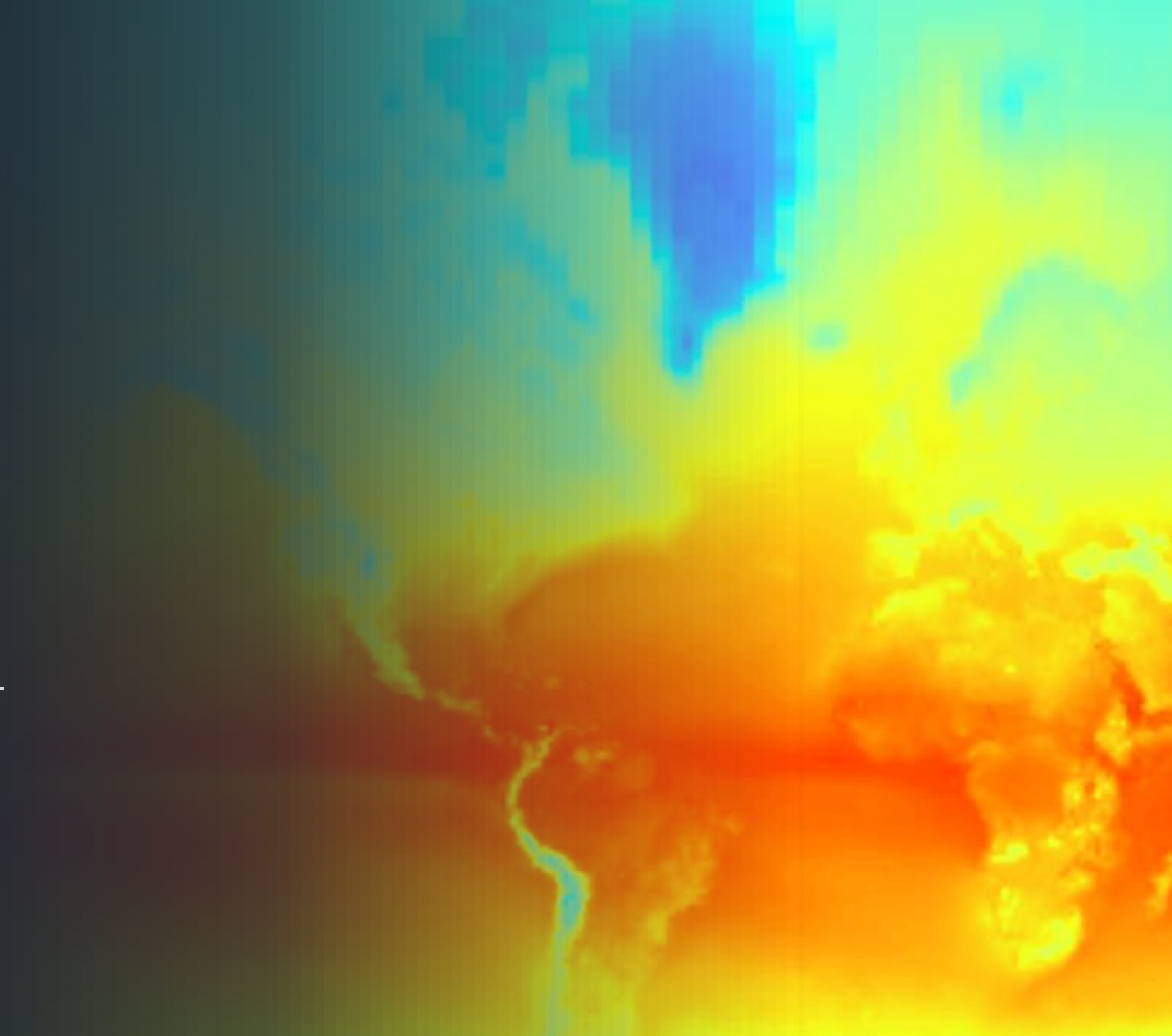
Why NASA?

- NASA develops, launches, maintains, analyzes, models, synthesizes and distributes data products from a large array of Earth viewing satellites.
- Earth Science develops these observations in themes related to Earth-atmosphere properties:
  - Atmospheric composition
  - Weather and Atmospheric Dynamics
  - Climate Variability and Change
  - Water and Energy Cycles
  - Carbon and Ecosystems
  - Earth Surface and Interior
- NASA Earth Science plans future improved observations that will impact knowledge and understanding of the Earth-atmosphere system.



Introduction to the POWER Project



Where does POWER Fit in NASA?

To foster the usage of NASA's observation and modeling data, **NASA's Earth Action Program** supports interaction and partnerships within US government, international agencies, large and small businesses and the general public to inform specific applications and decisions in these key areas:

Energy Resources
new!

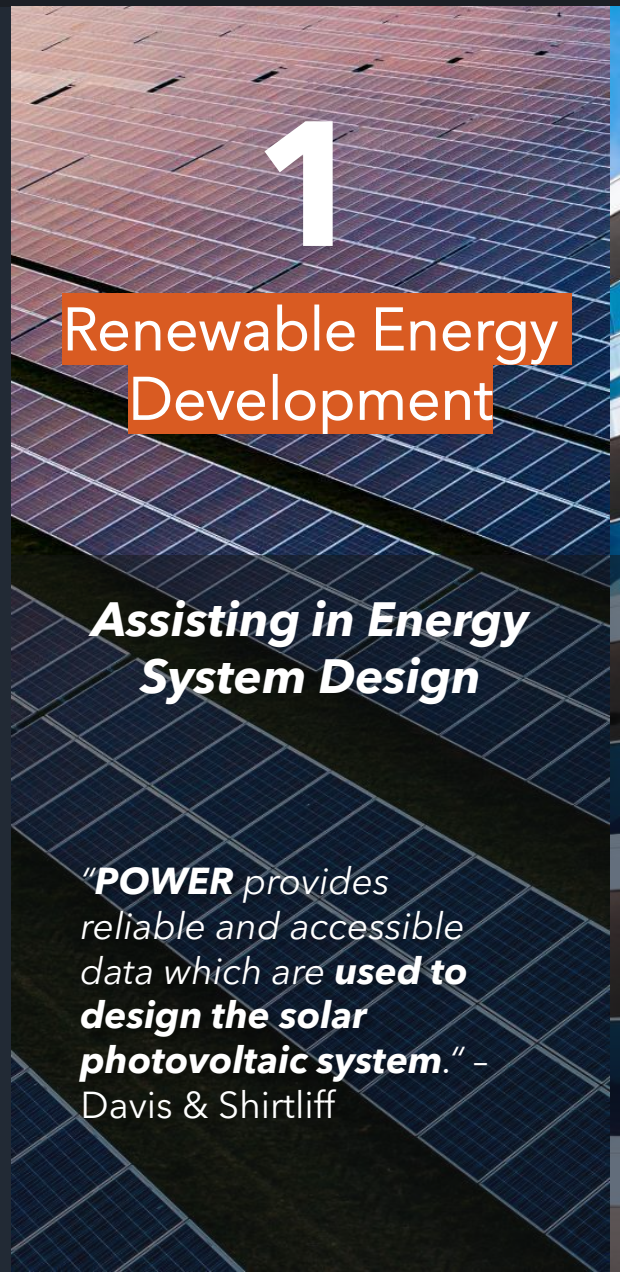
- **Earth Mission Engagement**
- **Wildland Fires**
- **Climate & Resilience**
- **Capacity Building**
- **Ecological Conservation**
- **Agriculture**
- **Disasters**
- **Water Resources**
- **Health & Air Quality**

The Prediction Of Worldwide Energy Resources Project

Research to Action: NASA POWER improves the capability to integrate NASA Earth Observations & model data specific to **surface solar irradiance** & **meteorological parameters** into decision processes related to energy, buildings, & agriculture.

Benefit Sector Relationships: Long-term partnerships, collaborations & user interaction within targeted benefit sectors provides critical feedback on needs.

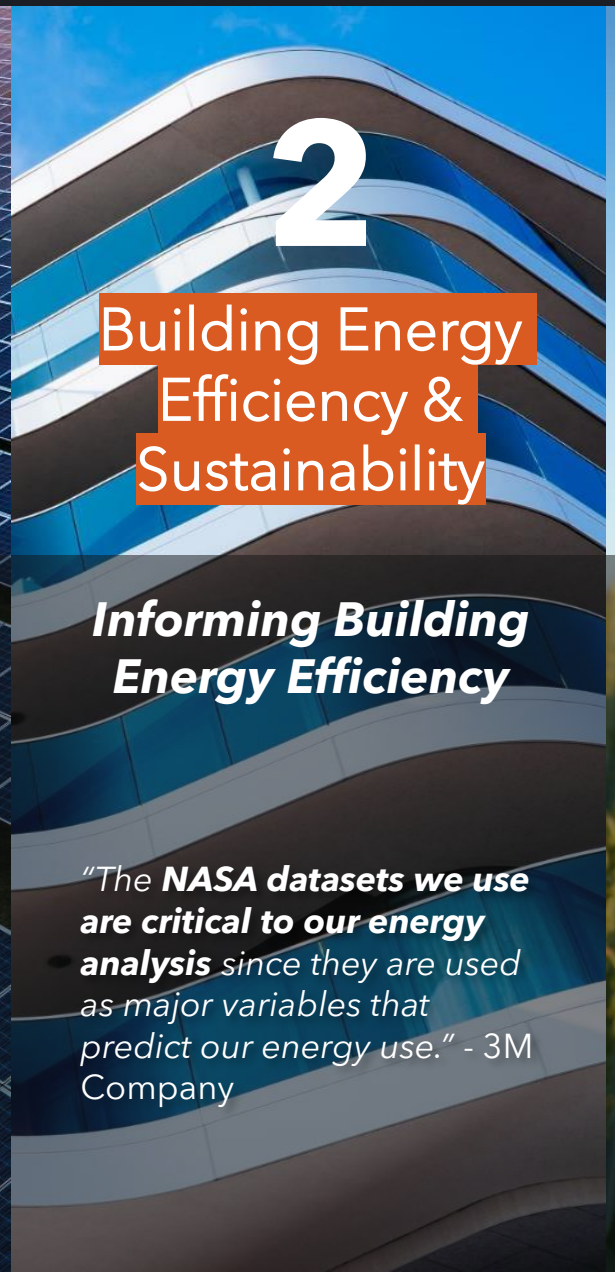
Accessibility of Validated Parameters: Processing & validating key user parameters, then developing IT infrastructure to provide information according to user requirements.



1 Renewable Energy Development

Assisting in Energy System Design

*"**POWER** provides reliable and accessible data which are **used to design the solar photovoltaic system**."* – Davis & Shirtliff



2 Building Energy Efficiency & Sustainability

Informing Building Energy Efficiency

*"The **NASA datasets we use are critical to our energy analysis** since they are used as major variables that predict our energy use."* - 3M Company

3 Agroclimatology Applications.

Enhancing Food Security

*POWER's customized, community-specific parameters used in **DSSAT** model helped in the "**Nitrogen fertilizer intervention response analysis** in Ethiopia maize".*

POWER's Support of National & Global Priorities

Domestic

- Federal Sustainability Plan
- U.S. 2030 Greenhouse Gas Pollution Reduction Goal
- U.S. Precision Agriculture Connectivity Act of 2018
- 2021 Federal Executive Order 14030
- 2021 Federal Executive Order 14057

International

- Paris Climate Agreement
- United Nations Sustainable Development Goals
- UN Sustainable Energy for All Initiative
- ISO 50001 Energy Management Systems
- International Energy Agency World Energy Outlook

Renewable Energy

Trends ~15%+

Expected growth per year through 2030

Sustainable Infrastructure

Trends 16-18%

Expected annual growth through 2025

Agroclimatology

Trends x2

Demand for data to double by 2029

NASA POWER aims to become a trusted, critical source in informing decisions that will reduce emissions and help achieve the **U.S. goal of Net-Zero Greenhouse Gas (GHG) Emissions by 2050**.

1. Hourly data and higher spatial resolution data to support building energy management, energy efficiency standards/benchmarking, & energy performance compliance requirements.
2. Reduced latency time that is important for building energy management applications.
3. Long-term (30 year) climate averages to be updated automatically every 5–10 years to support feasibility studies, design, & policy analysis.
4. Climate change projections of key parameters to support climate risk assessment for energy planners.

https://www.sustainability.gov/federalsustainabilityplan/index.html

How has POWER evolved over 25 years?

LaRC ASDC, DOE NREL, RETscreen International — *USGS, ASHRAE* — *DSSAT* — *IEA* — *ESRI*

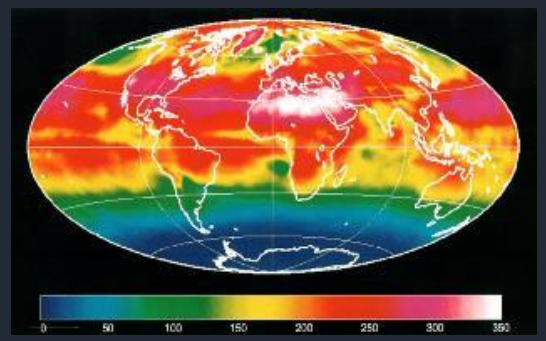
Sustainable Building Community

Near Real Time (NRT) Data Availability

Web-Based Data Visualization, API, & GIS Capability Added

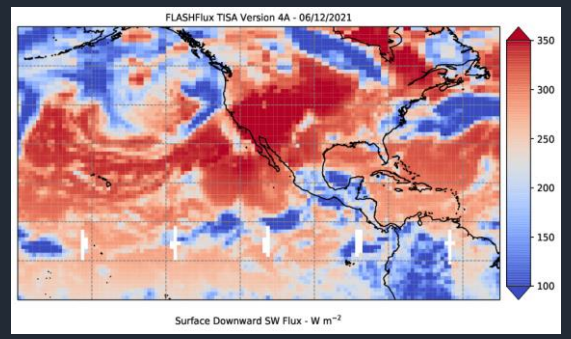
1997-1999 — **2004** — **2006** — **2008** — **2012** — **2018** — **2021-2022**

Surface Meteorology & Solar Energy (SSE)



WCRP SRB v1

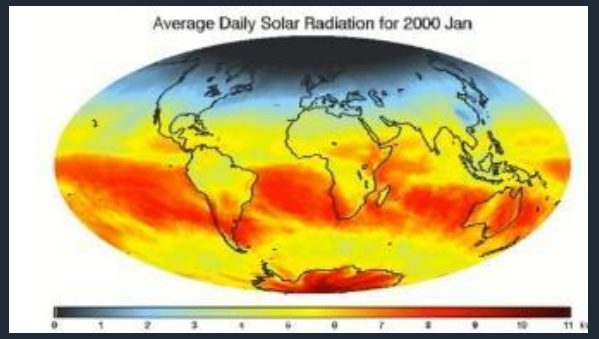
Daily Time-Series Data & Agriculture Community



CERES FLASHFlux

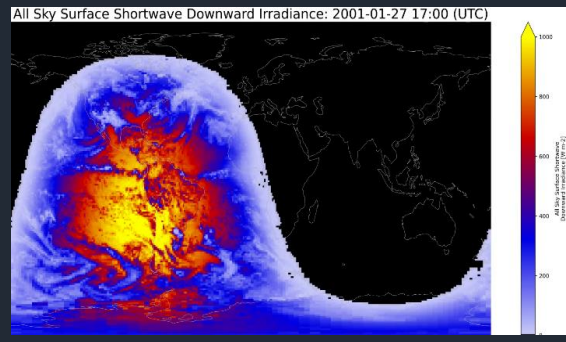
Total Data Requests exceeding 326 million

Enhanced Climatology Data Availability



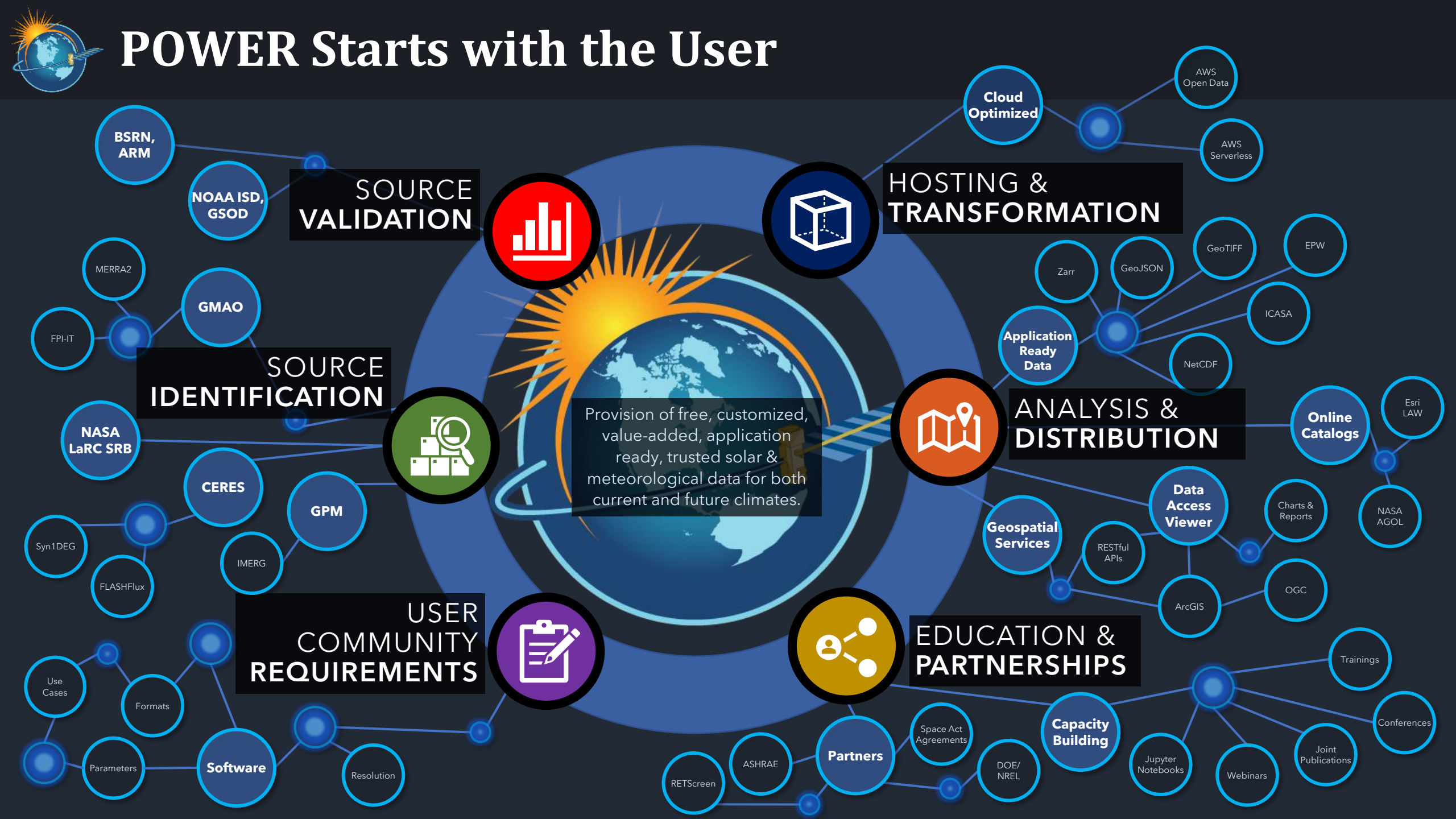
WCRP/GEWEX SRB v2.5

Hourly (2021) & Cloud Based (2022)



CERES SYN1Deg

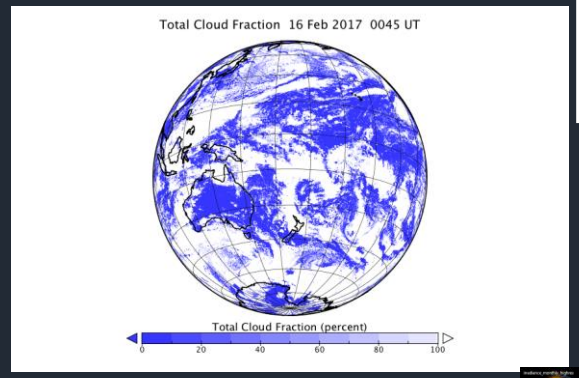
POWER Starts with the User



Where do POWER's Data Parameters Originate?

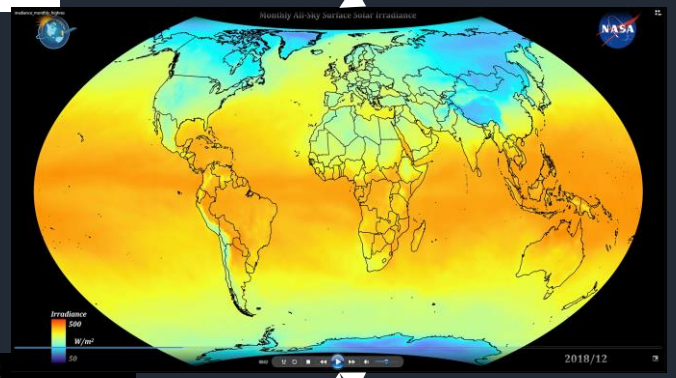
Surface Solar and Thermal IR Irradiance

SRB (1984-2000)

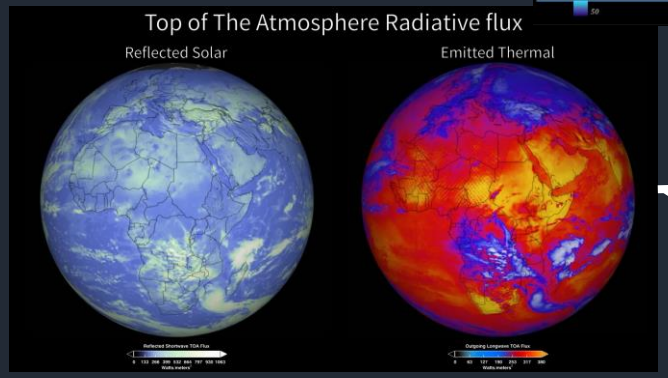


Atmosphere, clouds, aerosol, and surface inputs data

LaRC RT algorithm



CERES (2001-present)



Full RT model (adjusted to TOA)

Atmosphere, clouds, aerosol, and surface inputs data

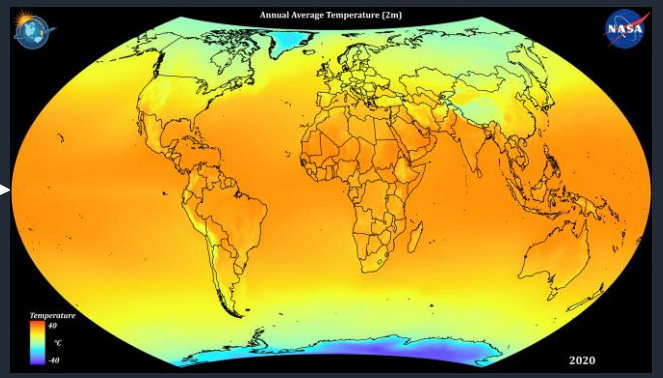
Surface Meteorological Parameters

Model (GCM)

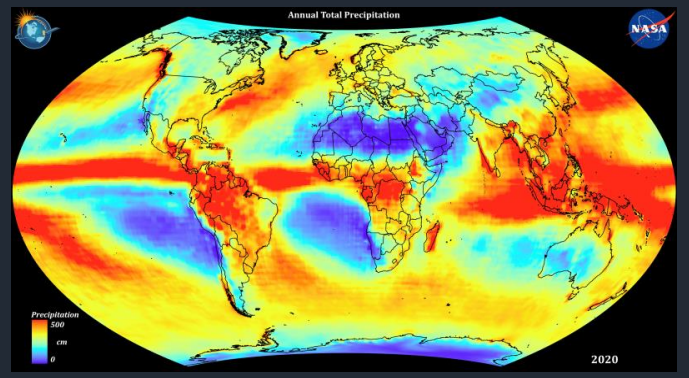
Observations: satellite, in situ, airborne

Assimilation (4DVar)

Atmospheric Reanalysis Output



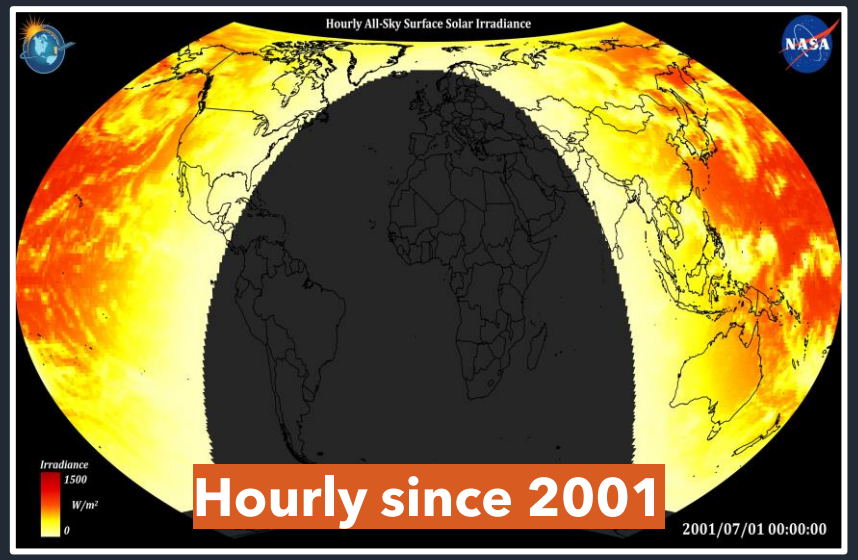
Daily Precipitation GPM IMERGE
(10 km, daily; 2000 - present)

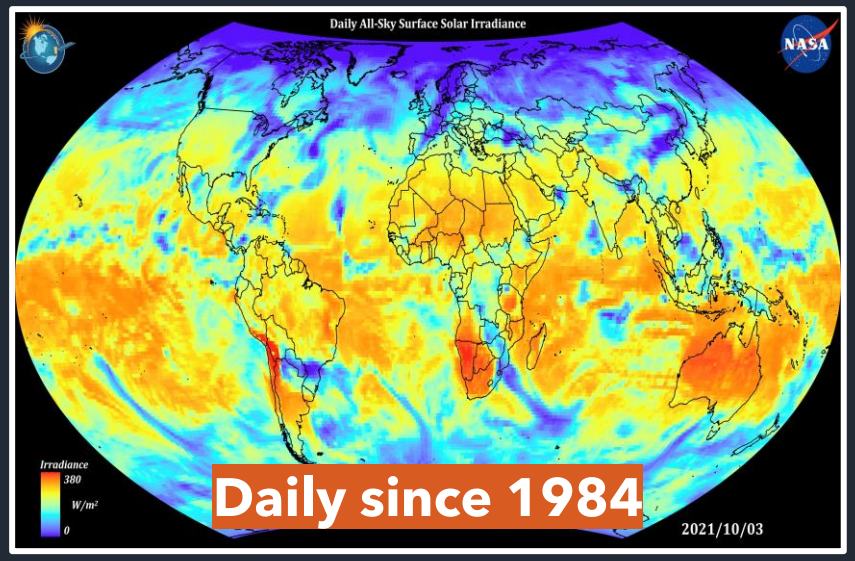


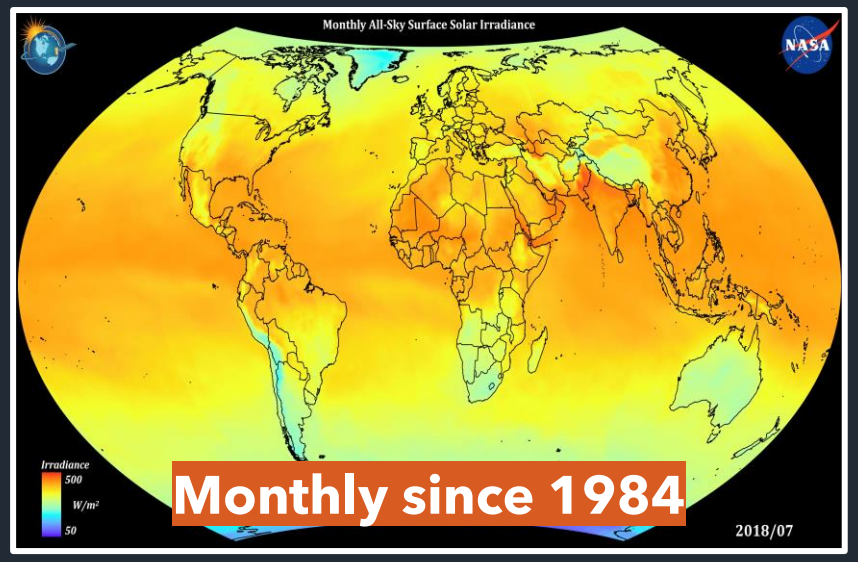
Data Products | Global Surface Solar Radiation

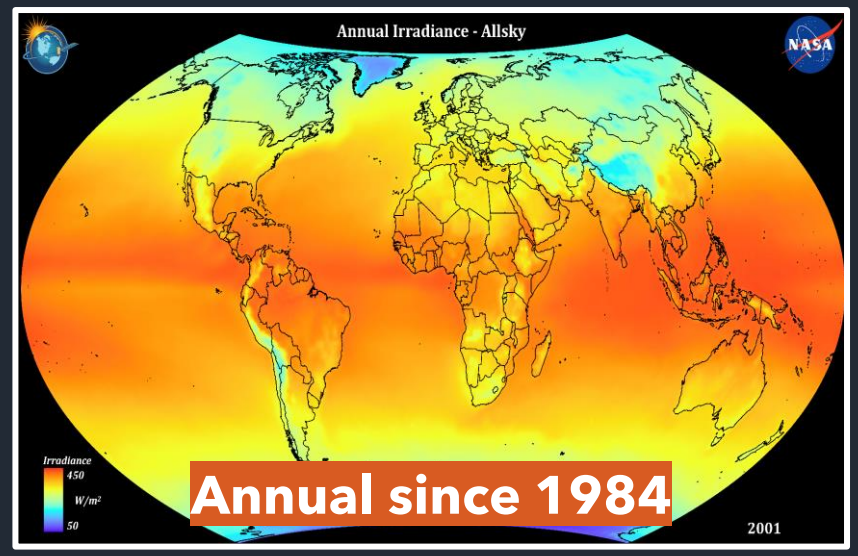
Sources:
- Before 2000: GEWEX SRB
- After 2000: CERES SYN1Deg

Latency within 3-4 days using CERES FLASHFlux







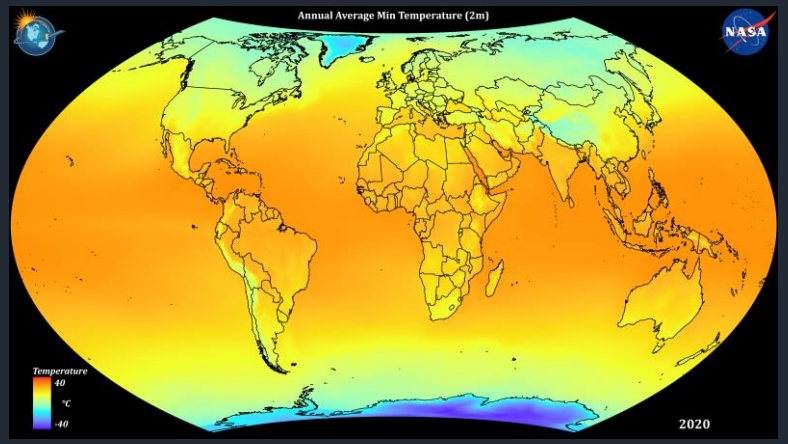


Example parameters:
- irradiance (longwave/shortwave & upward/downward)
- UV index
- earth skin temperature
- cloud amount
- aerosol optical depth

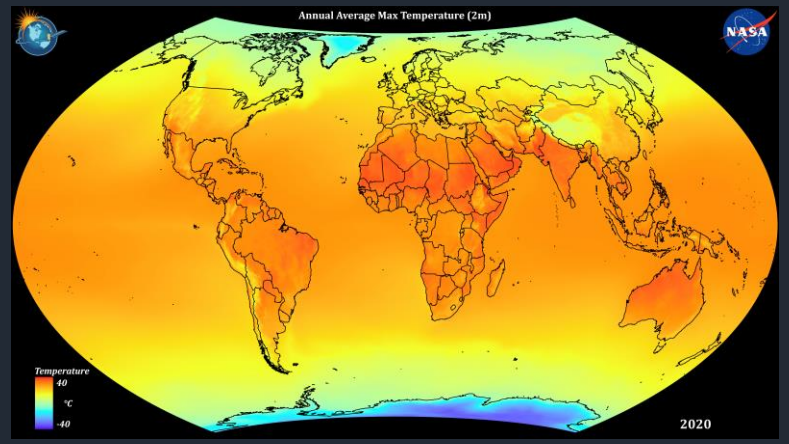
Climatological averages are also available!

Data Products | Global Surface Meteorology

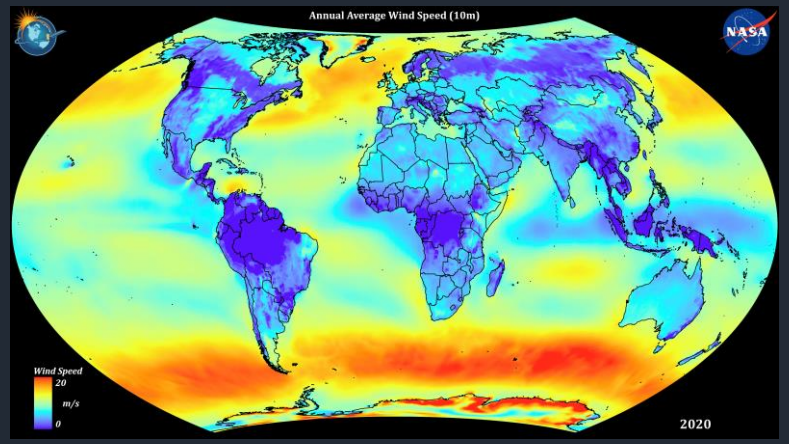
Source Data Product: GMAO MERRA-2



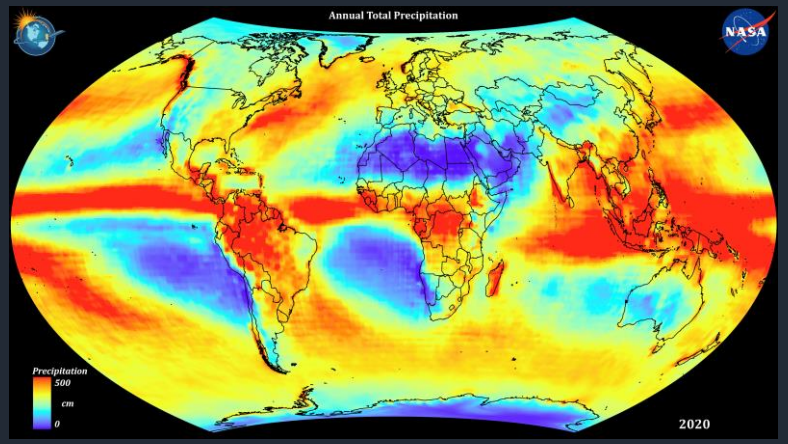
Temperature Min (2m)



Temperature Max (2m)

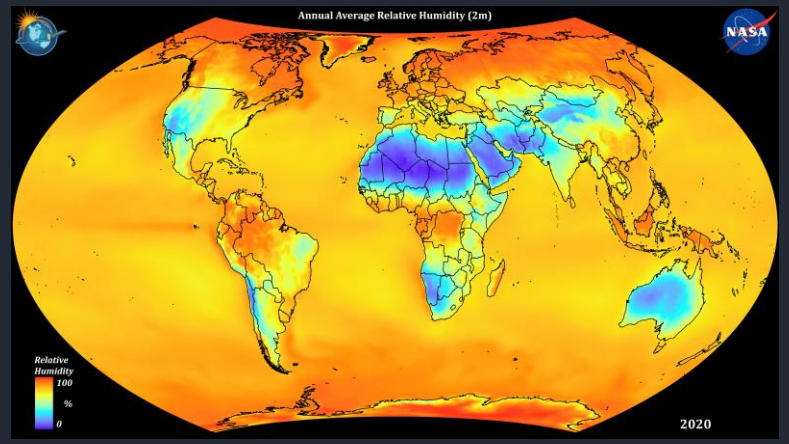


Wind Speed (10m)



Precipitation (cm)

(API Offers IMERGE too)



Relative Humidity (2m)

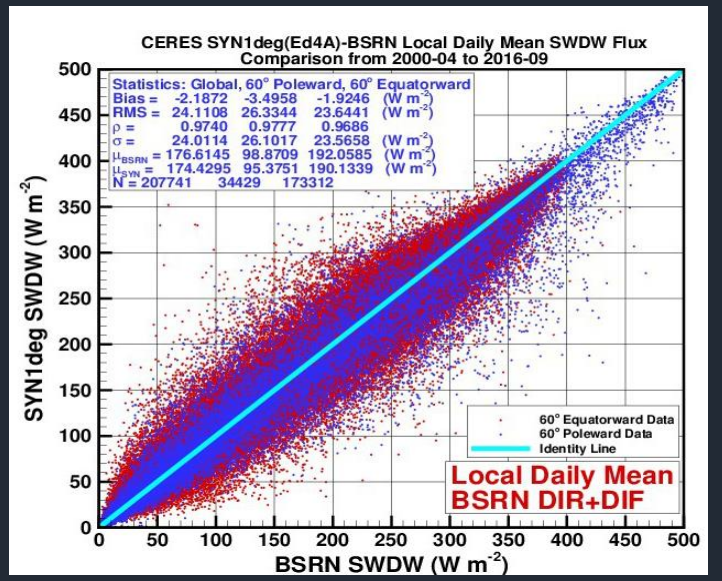
- **Time Span**: since 1981 up until near real time
- **Temporal Scales**: hourly, daily, monthly, annual, climatological averages
- **Example parameters**: heating/cooling degree days, snow precipitation, soil wetness, & surface pressure

How do we determine data parameter quality?

POWER uses surface measurements to characterize data product uncertainty

Validation at various temporal scales (up to hourly) and assessments for value-added products as observations available

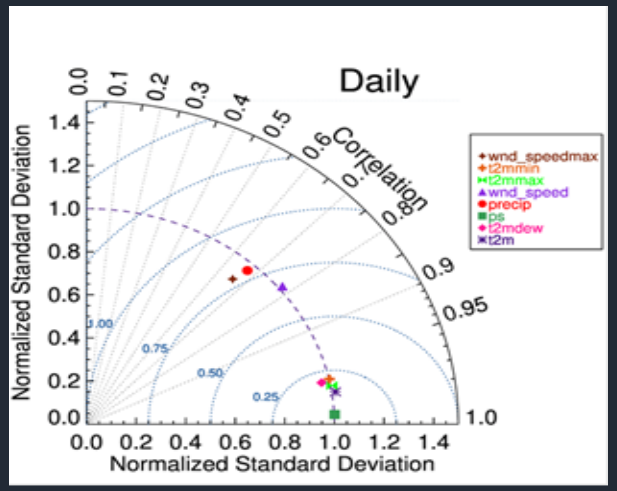
See "Methodology Documentation" pages for more information and statistics



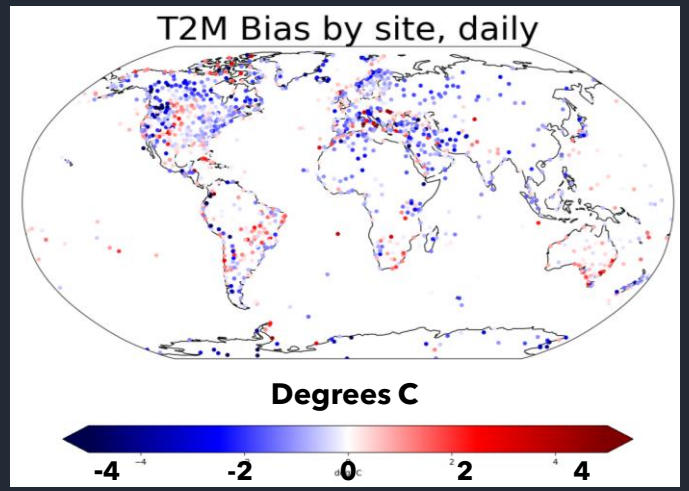
BSRN = Baseline Surface Radiation Network

DIR+DIF = best estimate of the surface solar irradiance

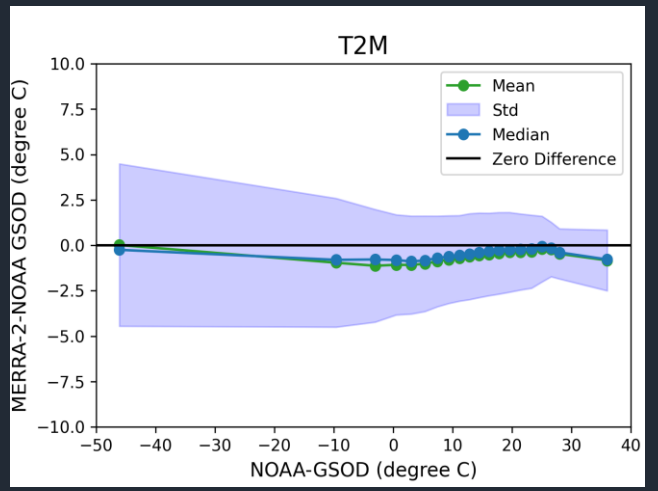
Merra-2 Daily Mean Fields



2m Daily Temperature: Bias Comparison from 1981 - 2020



2m Daily Temperature Differences



Tools & Services

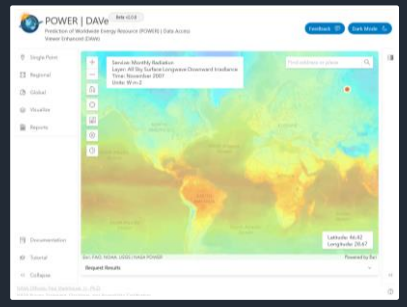
Enhancing Accessibility & Imagery

Application Programming Interface (API)

The API delivers ARD for inputs to decision support tools, modeling and forecasting packages, and as inputs to scientific research.

The API allows for direct integration into external applications and custom user scripts; users can submit a request and a RESTful response will be returned in a web-compliant JSON standard.

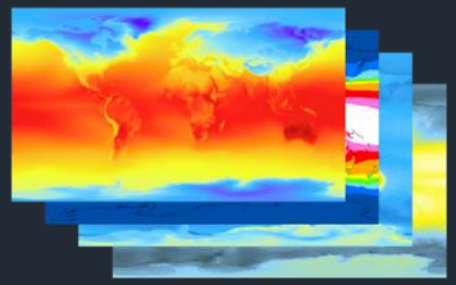
Data Access Viewer Enhanced (DAVe)



This application is a web-based data access service for a customized selection of parameters that provides a simple user interface built for mobile and desktop use.

The DAVe allows users to select community specific parameters, units, time periods, and output formats to efficiently retrieve data from the POWER Archive.

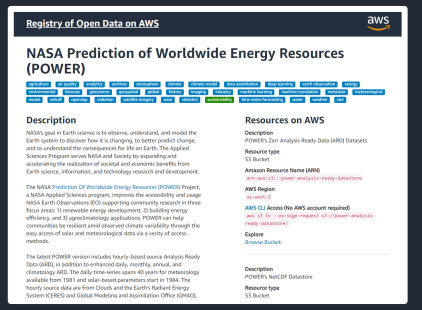
Geospatial Services



POWER provides Esri® ArcGIS Image and Feature Services allowing users to efficiently interact with the POWER data in Geographic Information System (GIS) applications.

New services for annual/monthly solar radiation and meteorology, available on: NASA ArcGIS Online (AGOL)'s POWER Group and Esri Living Atlas of the World.

Amazon Web Services



The POWER AWS allows users to directly access the POWER Analysis Ready Data (ARD) of ~8.5TB. The data follows open standards: OpenAPI, GeoJSON, and more.

POWER AWS services are near real time (NRT), as soon as source data becomes available from our source data providers:

- Meteorological: ~2-3 days
- Solar ~5-7 days

Key Differentiators for POWER Products & Services

Multi-decadal, high-accuracy, community-specific datasets

Hourly, daily, monthly, annual, & climatology scales w/ global coverage

Numerous access options ranging from an API, user interface application, & geospatial services

Customized data products, units, & formats for specific user communities *(improves usability & lowers adoption costs)*

How do we serve application-ready data to our users?

APIs

The Application Programming Interface (API) delivers Analysis Ready Data (ARD) for inputs to decision support tools, modeling and forecasting packages, and as inputs to scientific research.

Data Access Viewer

This application is a web-based user interface to enable no-code access to community-specific POWER data, providing subsetting capabilities for desktop and mobile use.

Geospatial Services

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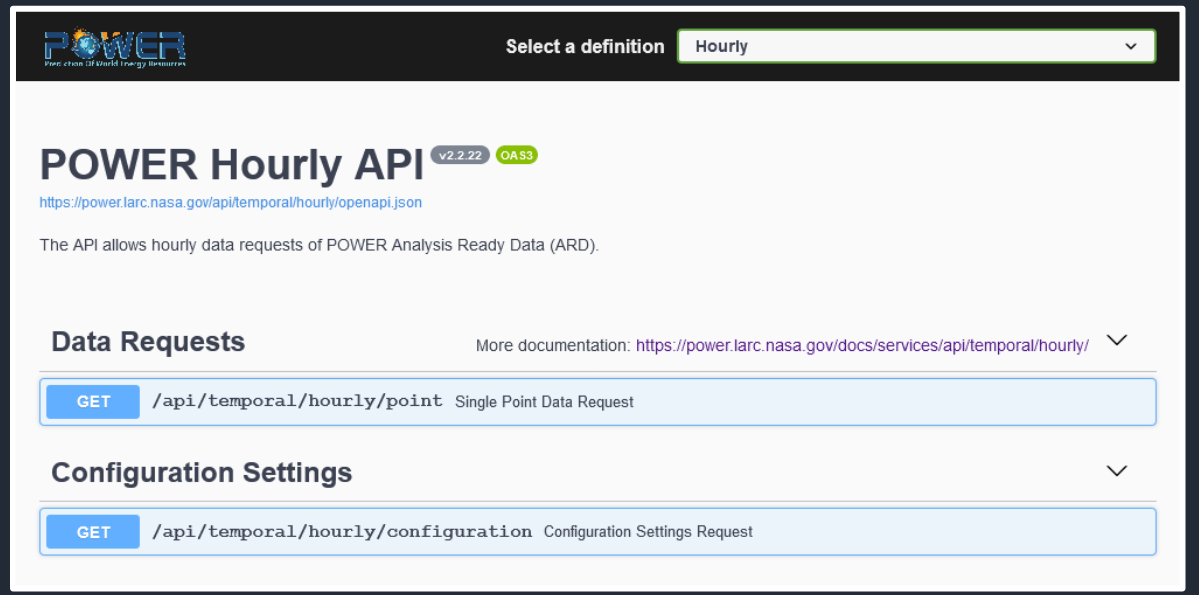
POWER's Application Programming Interface (API)

The POWER API delivers Analysis Ready Data for inputs to decision to support tools, modeling and forecasting packages (i.e., NREL's Solar Advisor), and as inputs to scientific research by providing:

- Complete access to entire database without having to use any other services
- **Direct integration into external applications; users can submit a request and a response will be returned without leaving their application!**
- Community-specific units and formats like ASCII, ICASA, CSV, GeoJSON, NetCDF, and more



Data Requests: ~140,000 a Daily

Follow Open Standards: OpenAPI, GeoJSON, and more

Example API Request:

https://power.larc.nasa.gov/api/temporal/daily/point?start=20210801&end=20210830&longitude=-4.75&latitude=-4.750&community=ag&parameters=ALLSKY_SFC_SW_DWN,T2M

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POWER's Data Access Viewer

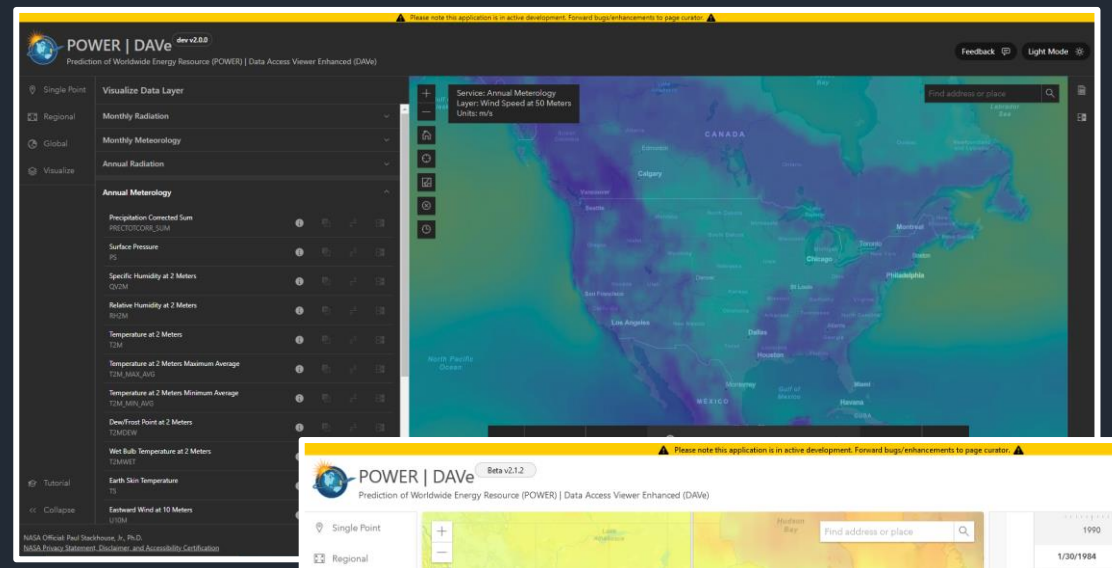
Enhanced user interface that enables:

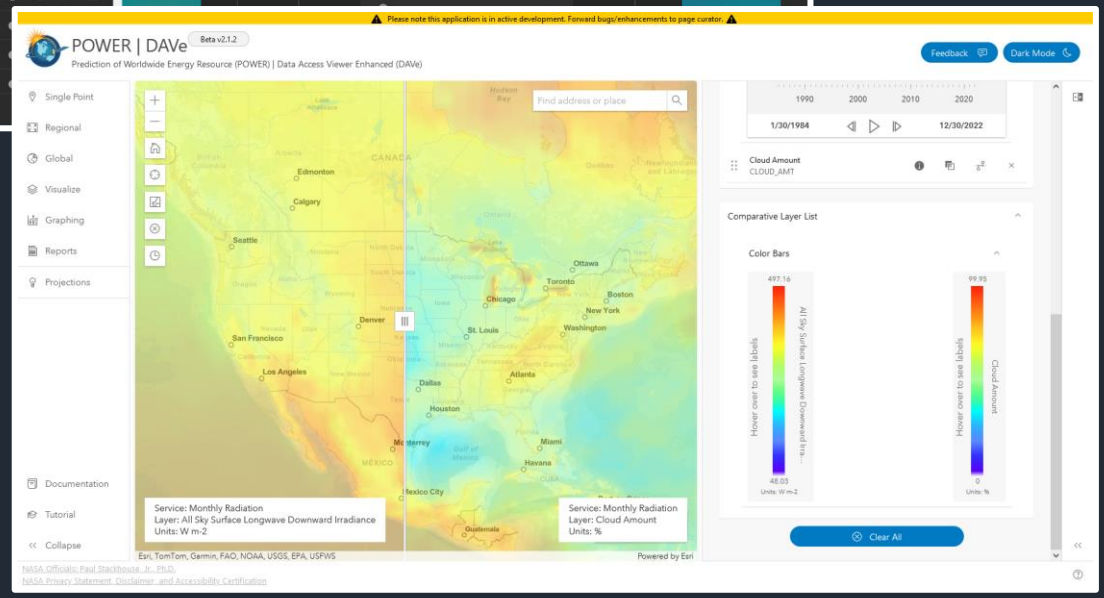
- Selection of groups of parameters based upon community standards and units
- Ability to download parameters in general & community specific formats

Visualization and charting of key data parameters such as:

- Thermal Zones
- Monthly Heatmaps
- Anomalies
- Annual Cycles

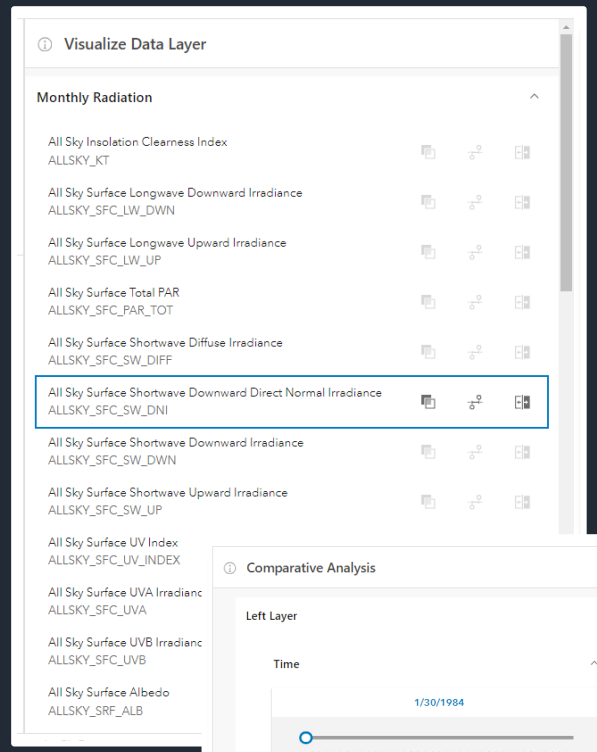
Integrated reporting capabilities such as **Climatic Design Conditions derived from ASHRAE®** equations & **new Climate Projections from the NASA Climate Adaptation Science Investigators (CASI) Program**

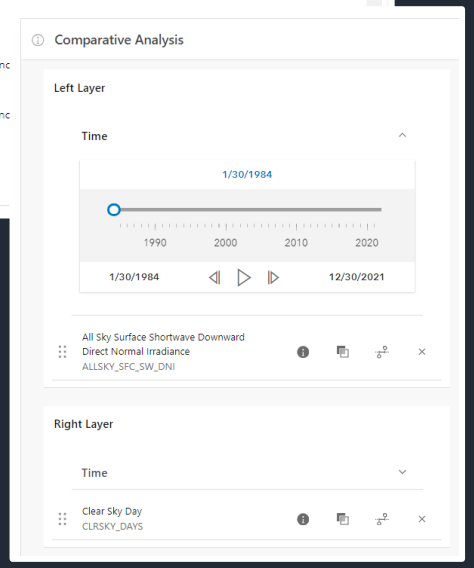




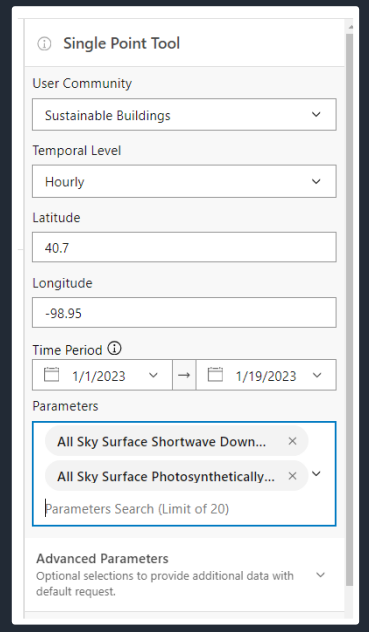
Leveraging the Esri® Calcite Design System to implement new user-driven requirements.

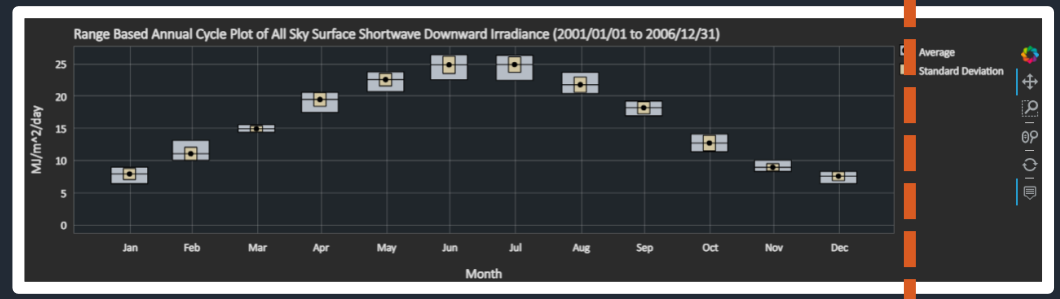
POWER's Data Access Viewer (enhanced)

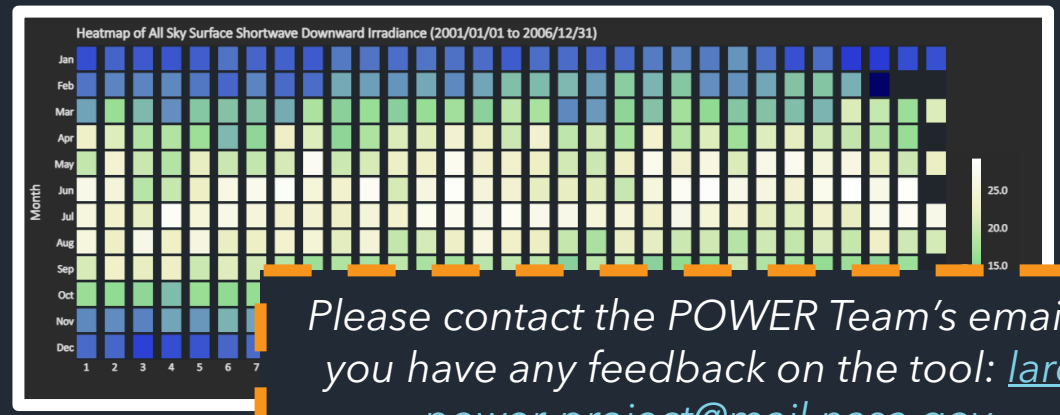




Users can find an interactive tutorial on the bottom left to get started & become accustomed to the available features.





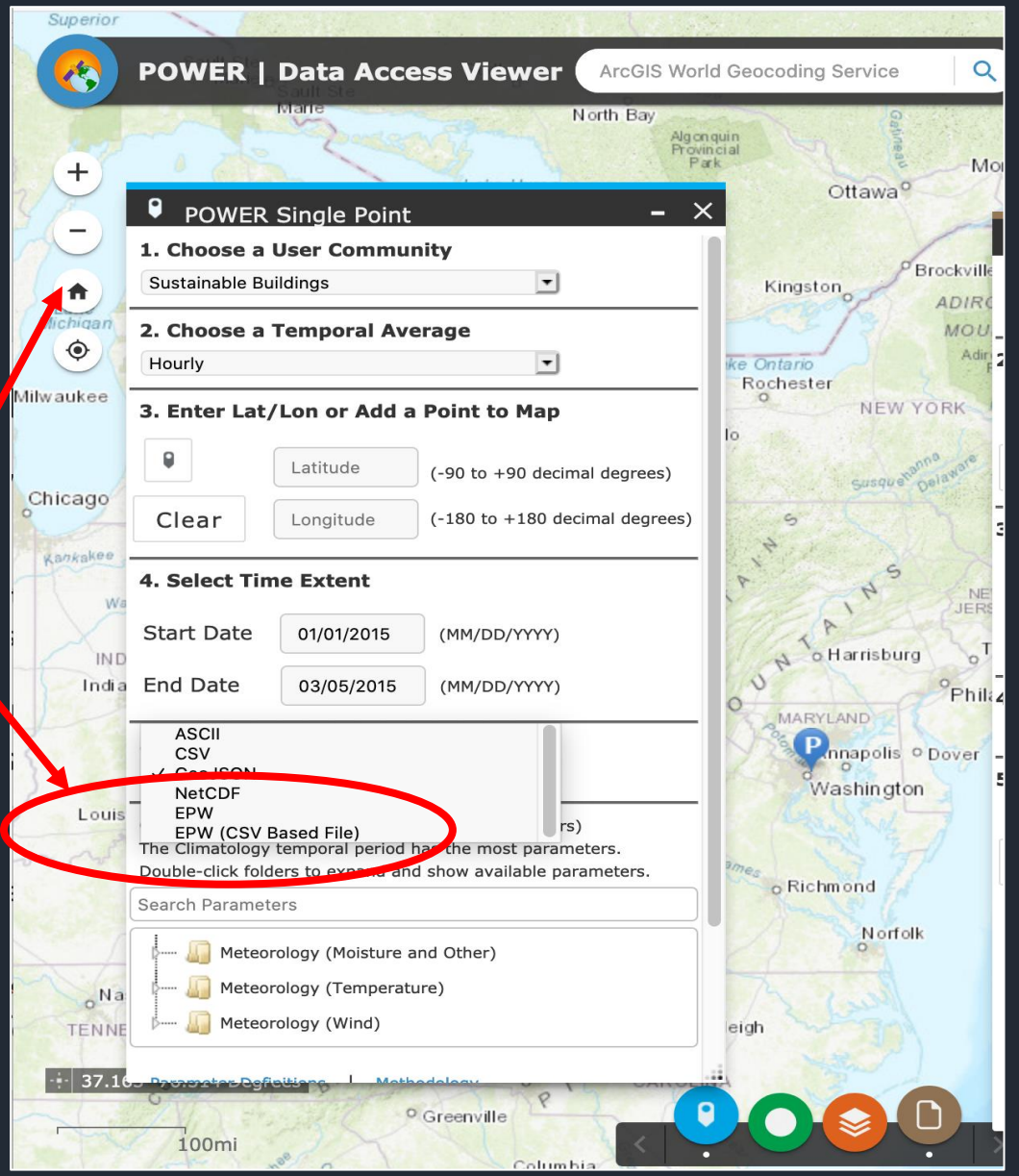


Please contact the POWER Team's email if you have any feedback on the tool: larc-power-project@mail.nasa.gov

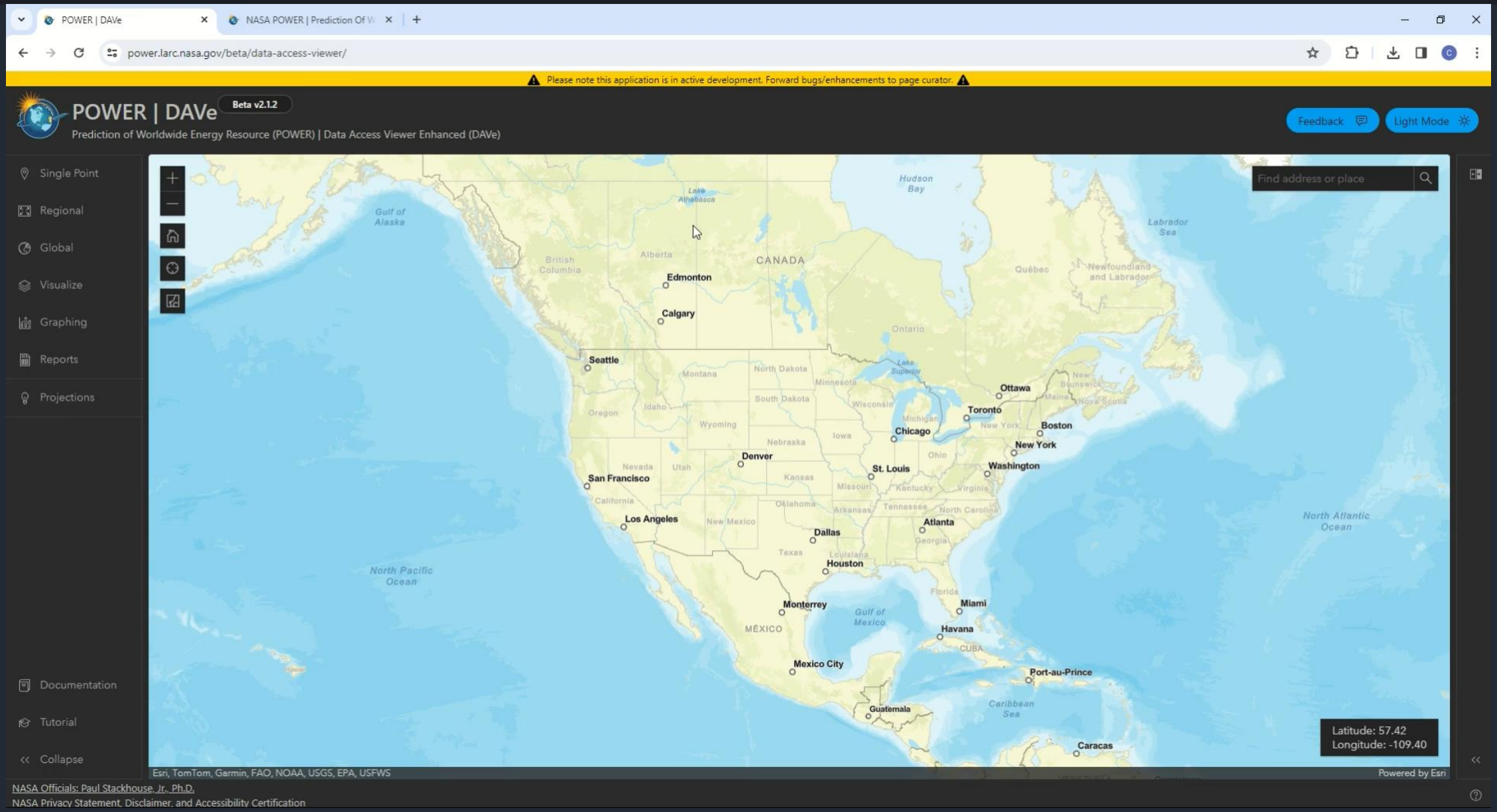
POWER: Custom Formats

Industry Standard EPW Format

- POWER supports 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.



Using POWER's Data Access Viewer: A Quick Demo



How do we serve application-ready data to our users?

APIs

The Application Programming Interface (API) delivers Analysis Ready Data (ARD) for inputs to decision support tools, modeling and forecasting packages, and as inputs to scientific research.

Data Access Viewer

This application is a web-based user interface to enable no-code access to community-specific POWER data, providing subsetting capabilities for desktop and mobile use.

Geospatial Services

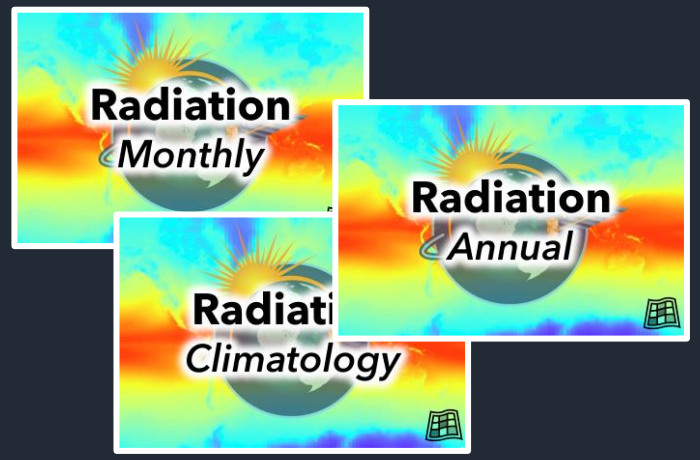
POWER provides Esri® ArcGIS Image and Feature Services allowing users to efficiently interact with the POWER data in Geographic Information System (GIS) software.

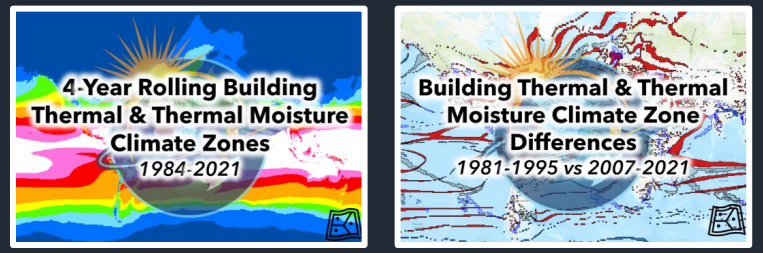
Amazon Web Services

The POWER AWS allows users to directly access the POWER Analysis Ready Data (ARD) of ~8.5TB. The data is Near Real Time (NRT), as soon as source data becomes available from POWER's source data providers.

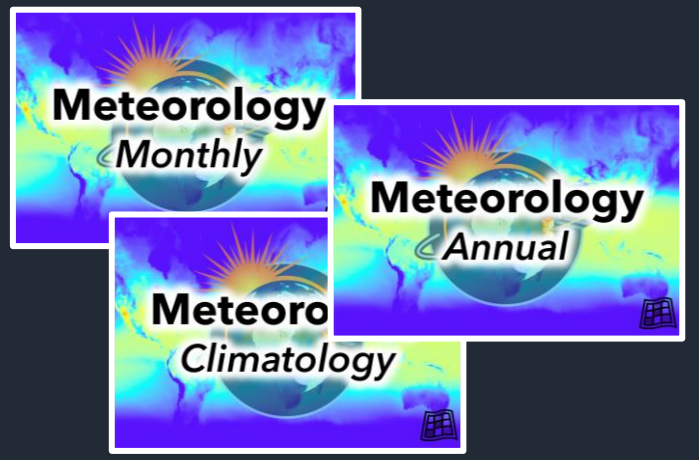
New Geospatial Feature & Image Services

POWER released 15 new/updated Esri® ArcGIS geospatial services. These services allow users to visualize & explore POWER datasets as well as enable the data to efficiently interact with GIS applications & tools. **Available on:** Esri Living Atlas of the World & NASA ArcGIS Online (AGOL)

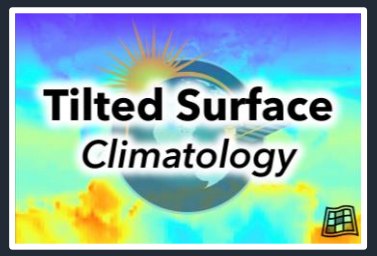




Climate Zones



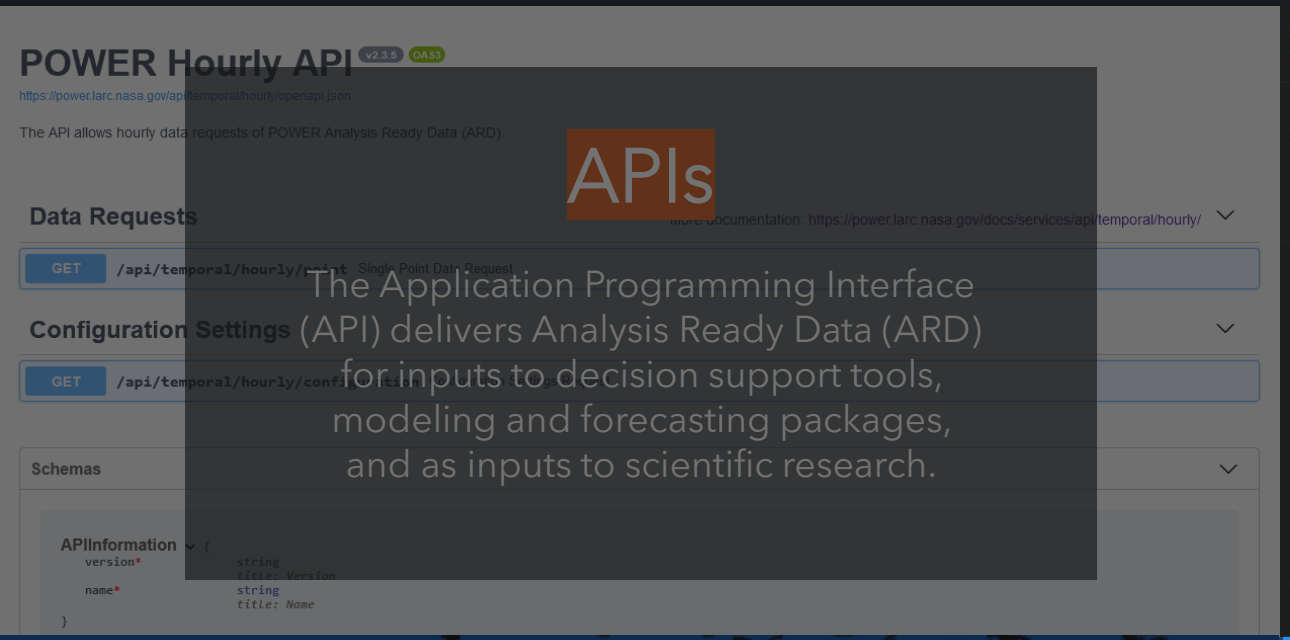
Solar Geometry



Climatologies

Esri®: is a registered trademark of the Environmental Systems Research Institute, Inc.

How do we serve application-ready data to our users?



APIs

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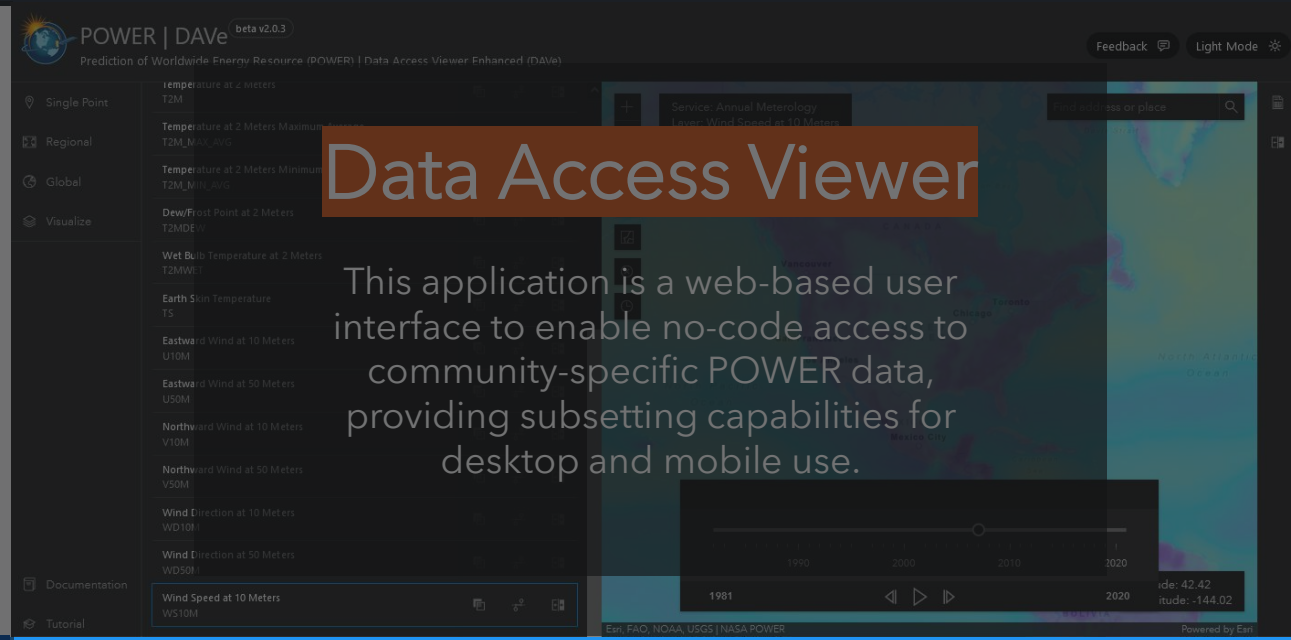

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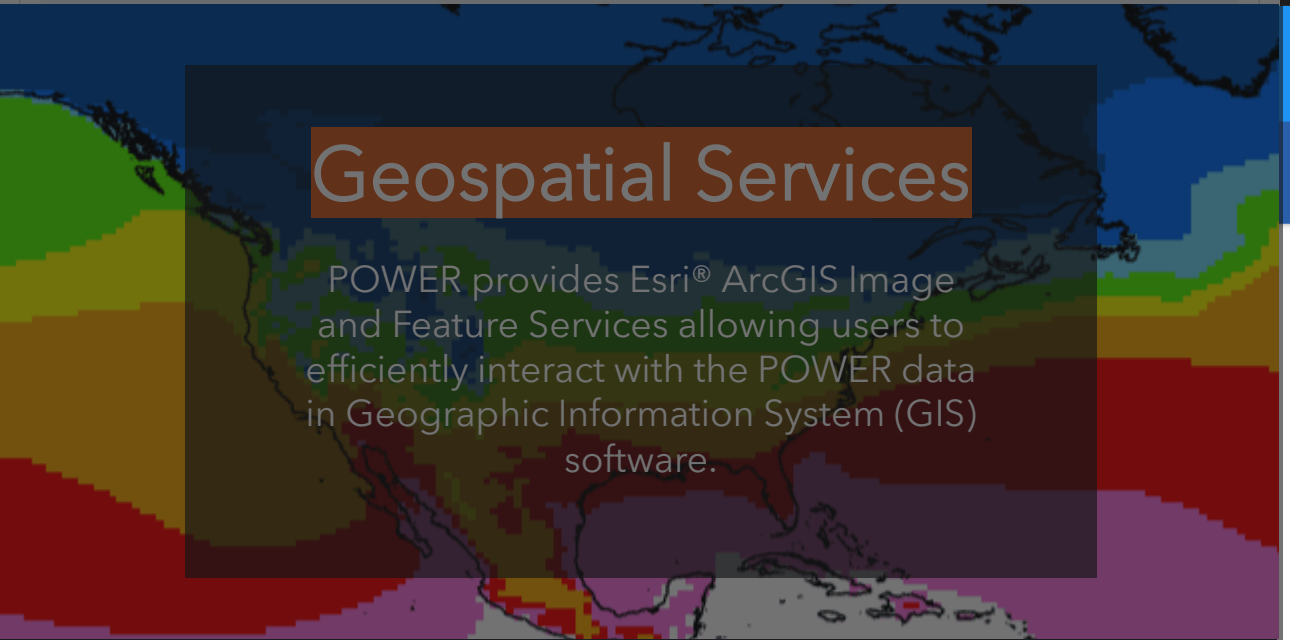

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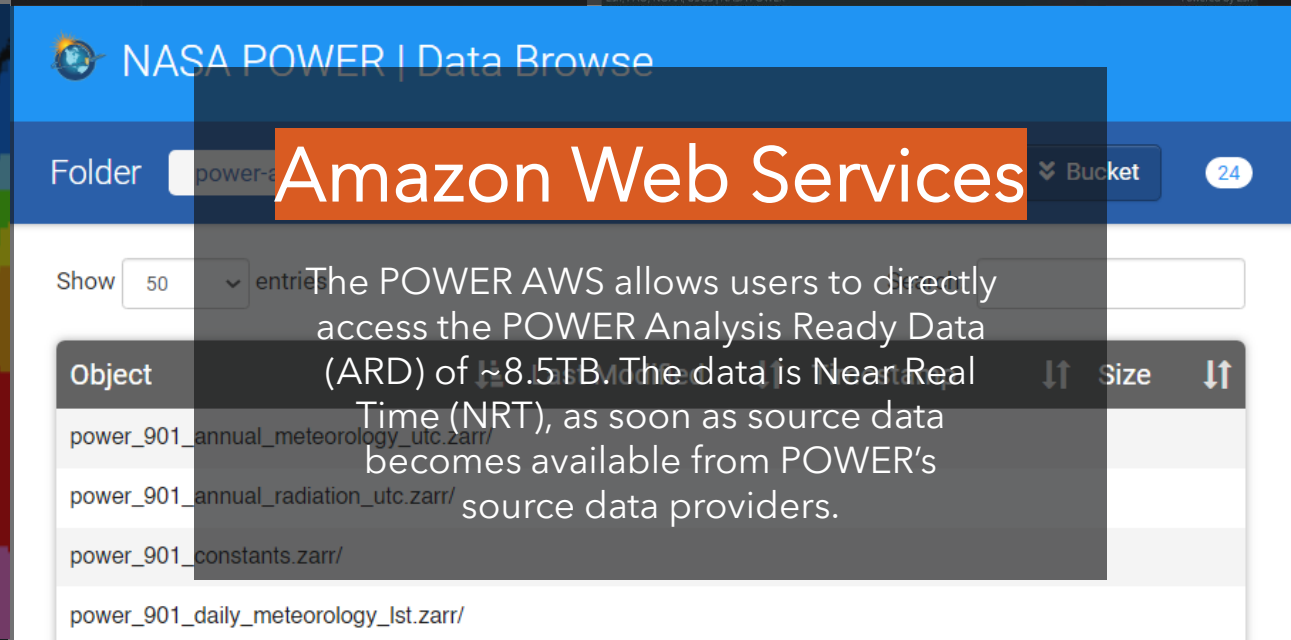


Amazon Web Services

The POWER AWS allows users to directly access the POWER Analysis Ready Data (ARD) of ~8.5TB. The data is Near Real Time (NRT), as soon as source data becomes available from POWER's source data providers.

POWER in the Cloud

Hosted Data Methodology, Documentation & Examples

Cloud-Optimized & Data Directly Accessible

RESTful API Supported by Scalable Serverless Architecture & DevOps

ANALYSIS & **DISTRIBUTION**

HOSTING & **TRANSFORMATION**

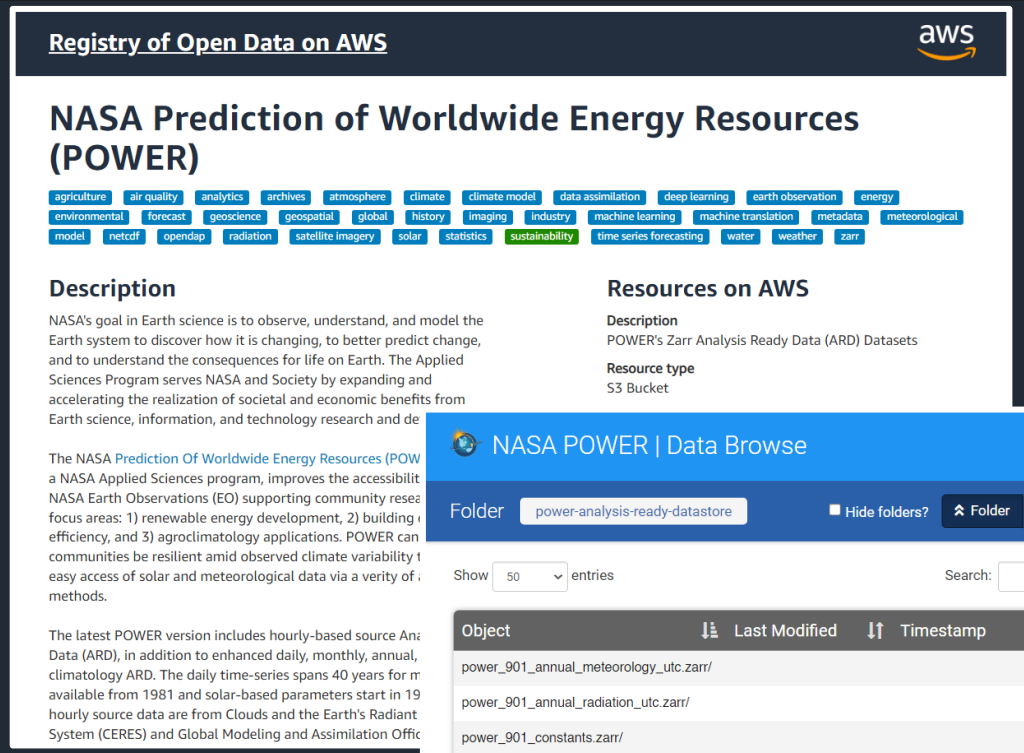
How do I access all the POWER Data directly?

The POWER AWS data store allows users to directly access POWER's entire Analysis Ready Data (ARD) ~8.5TB catalog.

- Near Real Time (NRT), as soon as source data becomes available from our source data providers.
  - Meteorological: ~2-3 days
  - Solar ~5-7 days
- Follow Open Standards: OpenAPI, GeoJSON, and more

Links:

- https://registry.opendata.aws/collab/nasa/
- https://registry.opendata.aws/nasa-power/
- https://power-analysis-ready-datastore.s3.us-west-2.amazonaws.com/index.html
- https://power-datastore.s3.us-west-2.amazonaws.com/index.html

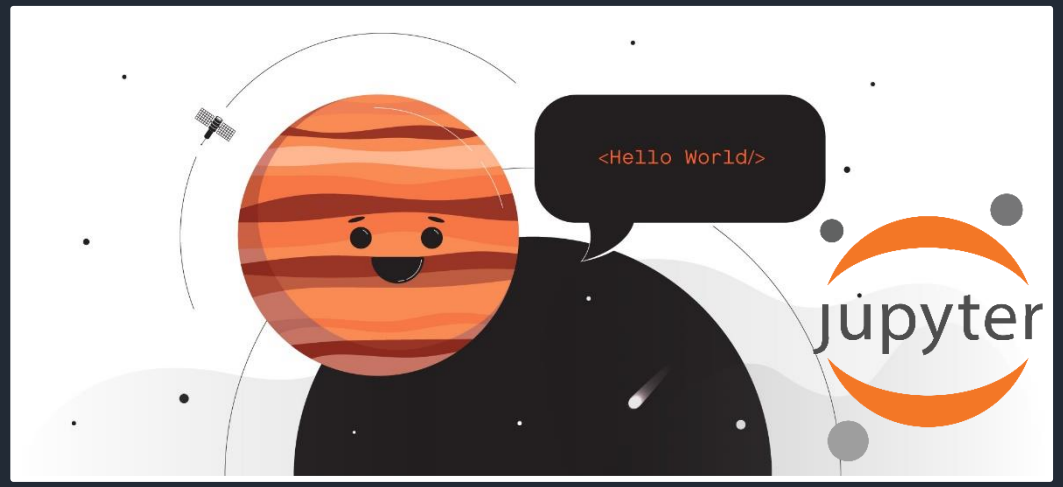


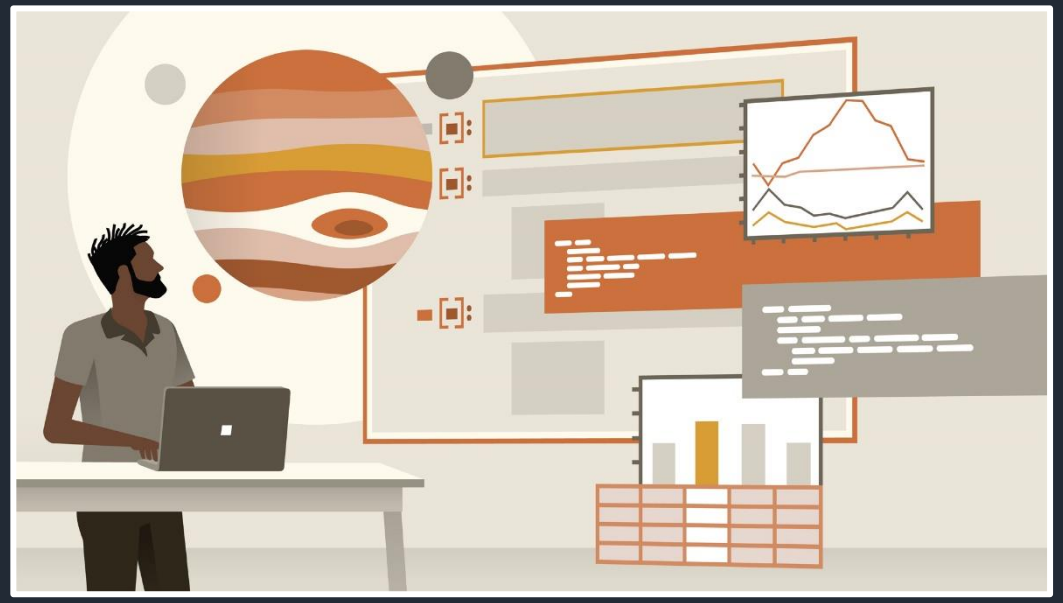
Analytics with Jupyter Notebooks

The POWER Project provides Jupyter® notebooks, available to:

- provide step-by-step instructions on how to use POWER's data services and tools.
- teach users how to interact with the POWER API without the need for additional software.
- demonstrate how to integrate POWER services into external applications.
- use Python to perform parameter analysis by creating tables and plots.

Hyperlink: NASA POWER API Access Notebook

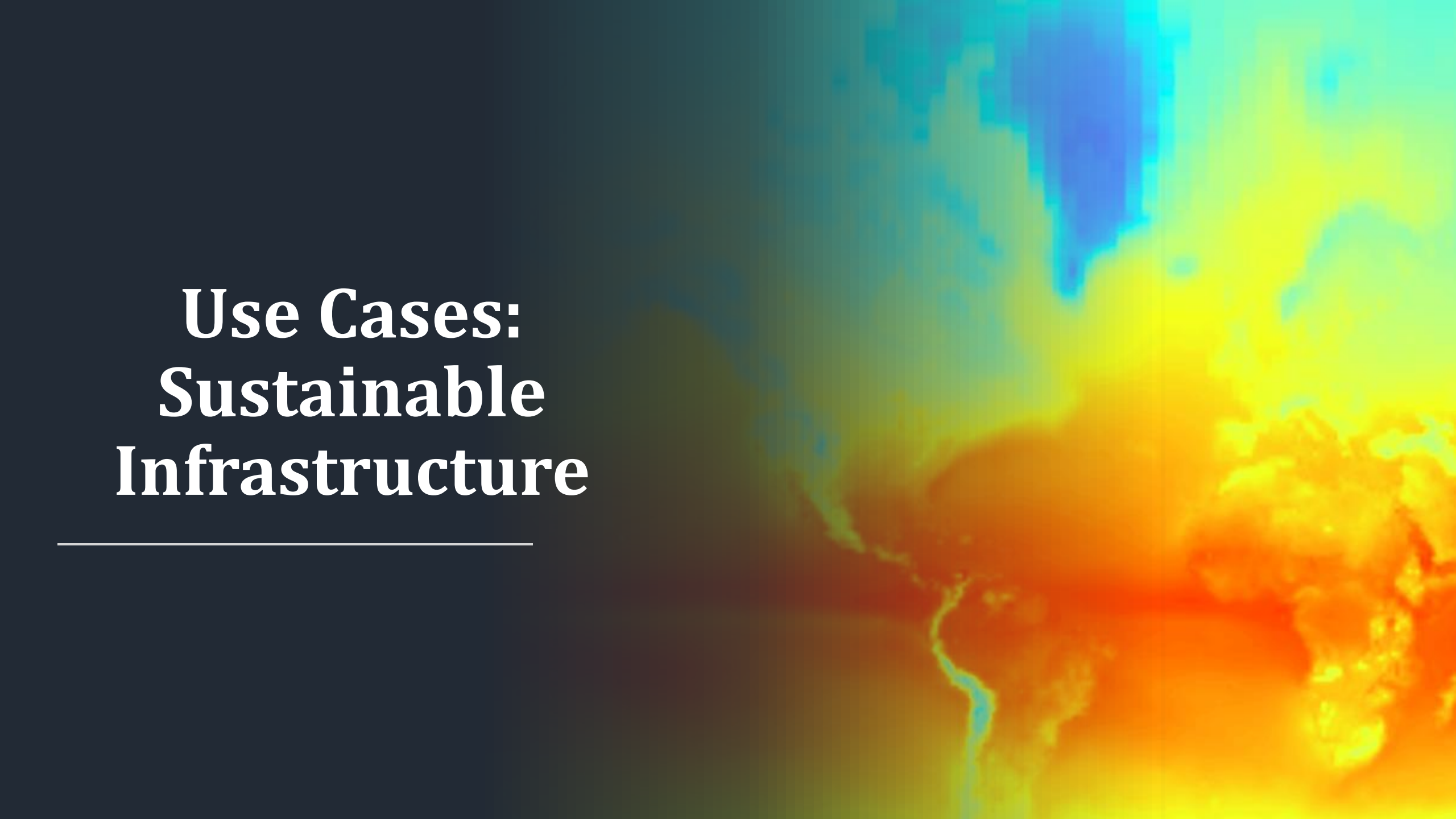




Images from the Jupyter Project's Website:https://jupyter.org/

Jupyter®: is a registered trademark of the Jupyter Project

Use Cases: Sustainable Infrastructure

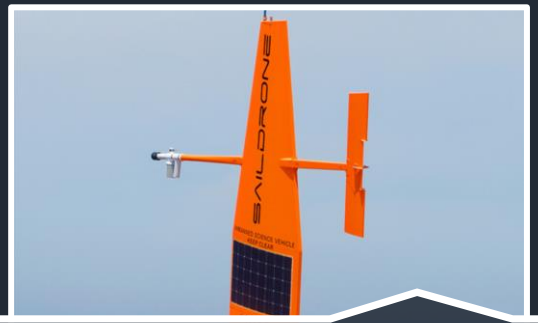


POWER Community: Impactful Projects

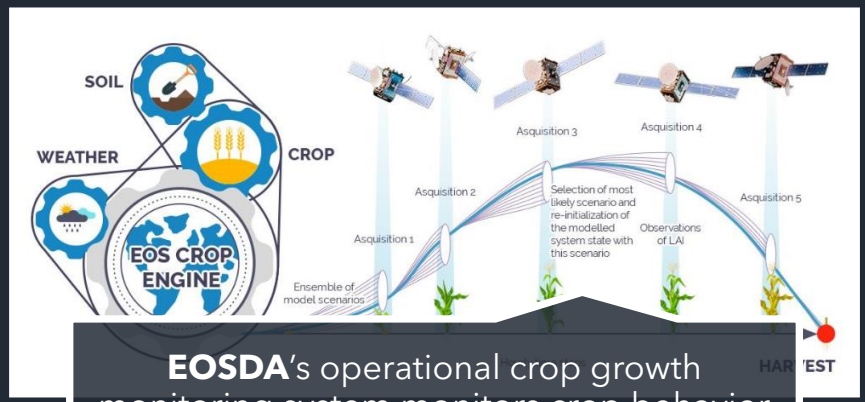
POWER is working with **ASHRAE** to create **Building Climate Zone Maps** for the globe, as well as "rolling" climate zones from 4-year means to illustrate the changes in time from 1984 through 2021.

Urban Solar uses POWER's API to retrieve minimum solar irradiance to then **manufacture & place solar power systems** & LED lightning solutions for applications such as transit, transportation & parking lots.

Argonne National Laboratory uses POWER data products to feed into **PV installation models** to develop probabilities of power generation over potential power outage windows.



Saildrone is using data from POWER to **determine viable operations season** & make strategic engineering tradeoff decisions for wind & solar-powered uncrewed surface vehicles.

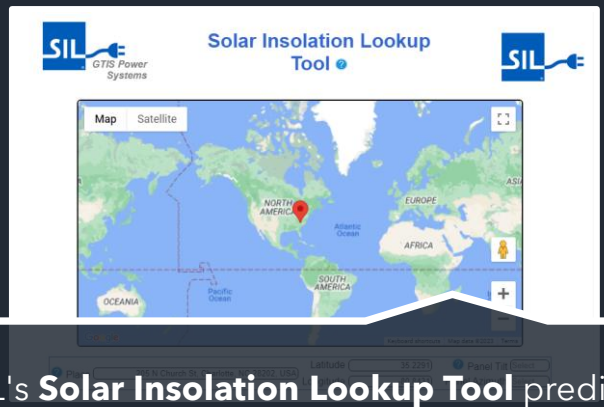


EOSDA's operational crop growth monitoring system monitors crop behavior & **produce crop yield forecasts**; POWER meteorological data is a key input to this system.

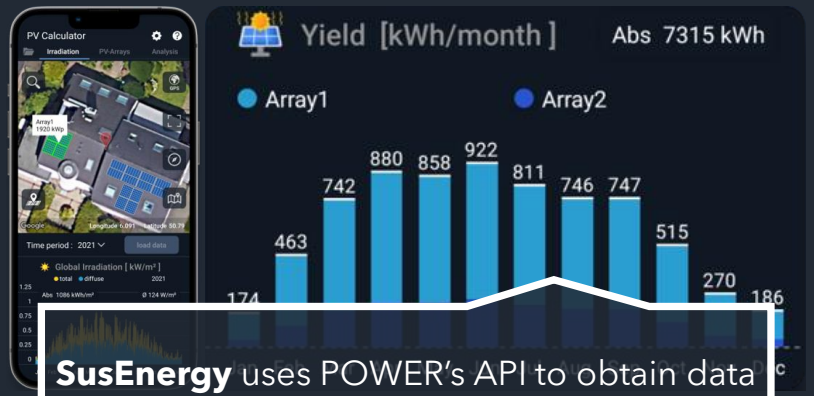
POWER Community: Impactful Projects

Natural Resources Canada's **RETScreen®** uses POWER climatological averages to calculate **feasibility & performance** related to energy efficiency, heating/cooling & power generation. **800k users**!

POWER data supports the **Decision Support System for Agrotechnology Transfer** tool, used for modeling crop yield prediction & **assessing the impact of climate change** on global food security.



SIL's **Solar Insolation Lookup Tool** predicts **power output from a solar panel** anywhere in the world using hourly data from POWER.



SusEnergy uses POWER's API to obtain data to feed into their app for **site-specific design** of photovoltaic & wind energy systems.

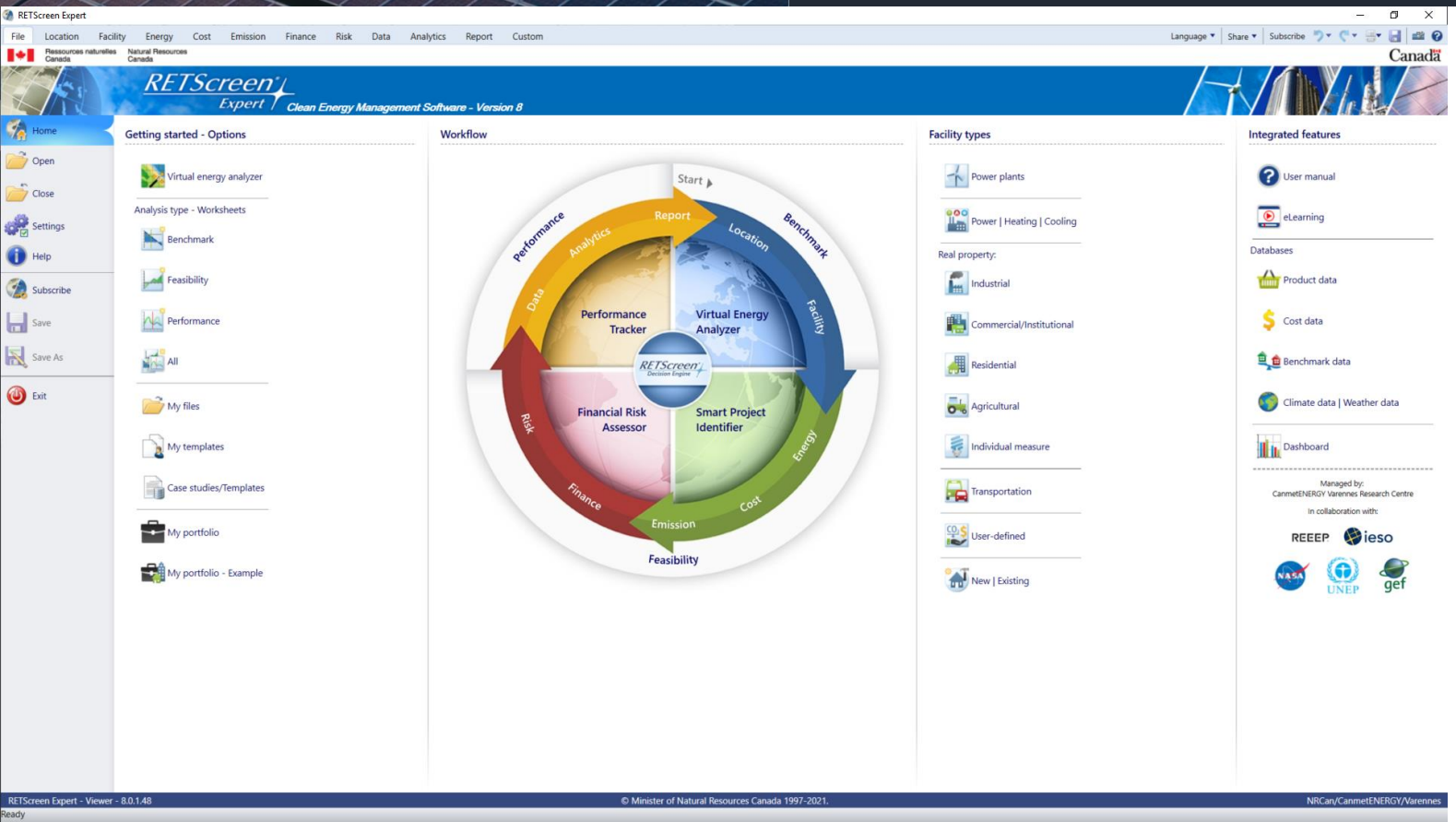
SolarCalc uses data from POWER to compute how many solar panels (including arrangement) are needed to power different types of **solar-powered water pumps**.

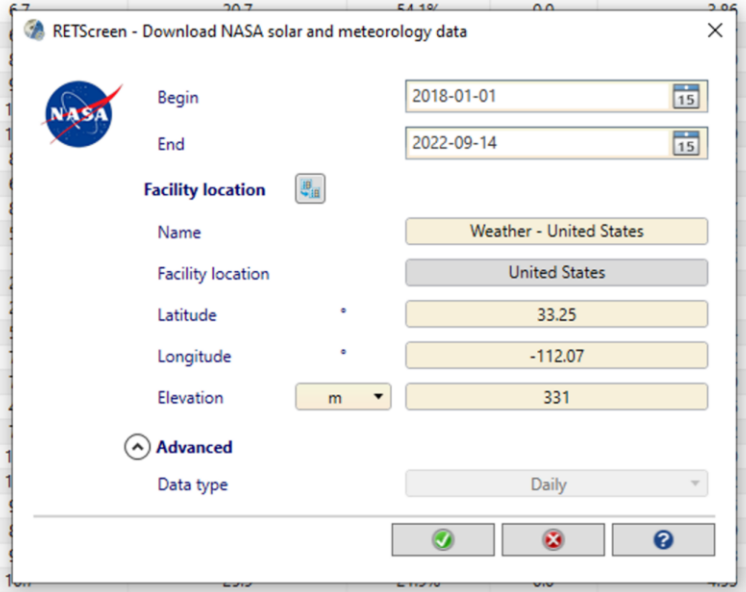
Renewable Energy Development

Natural Resources Canada's RETScreen® Clean Energy Management Software Platform

World's leading clean energy decision making software for benchmark, feasibility, performance, and portfolio analysis related to energy efficiency, heating/cooling, power generation, and cogeneration, with 800,000+ registered users.

POWER provides global data as climatological averages that are embedded in the software and near-real time data obtained via a direct connection to POWER.





12.2	25.1	32.1%	0.0	3.15
12.6	23.4	26.2%	0.0	2.33
12.3	23.1	48.4%	6.6	2.52
9.4	16.1	72.8%	3.2	2.91
9.1	26.5	24.3%	0.0	4.60
10.9	26.4	22.8%	0.0	4.58
10.8	25.7	22.3%	0.0	4.70
9.2	25.8	18.9%	0.0	4.83
10.4	28.6	14.9%	0.0	4.96
9.8	27.7	16.9%	0.0	4.98

RETScreen®: is a registered trademark of the Government of Canada's Natural Resources Canada.

Sustainable Infrastructure

RWDI (Rowan Williams Davies & Irwin, Inc.) Consultants

RWDI helps engineers, architects, & designers understand how their buildings interact with the sun, with the goal of minimizing each project's impact on the natural world. RWDI has been involved in solar and thermal comfort related work for hundreds of projects across all 7 continents.

Their studies routinely help shape the design of the individual buildings as well as campus or city-scale urban design. Before discovering the POWER Project, RWDI found high quality, global solar data hard to come by. Now, POWER data is used within the suite of their in-house analysis tools.

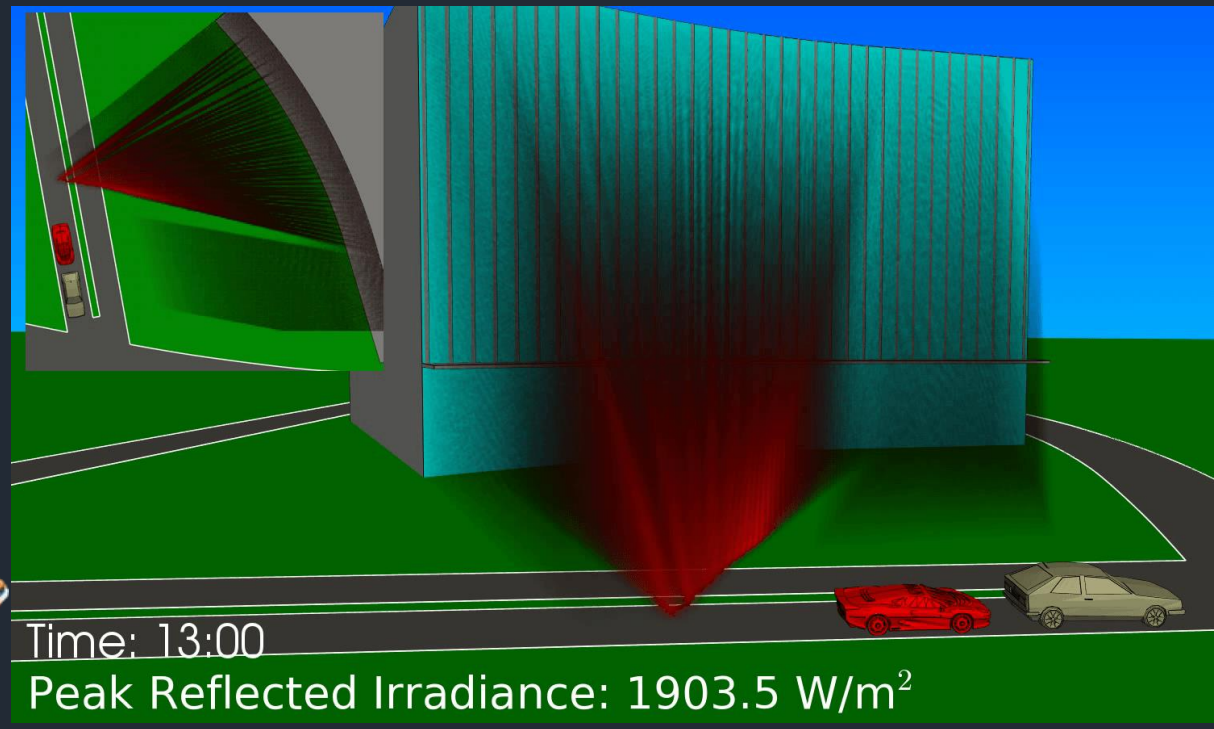


Image & GIF created by RWDI, Inc. Consultants

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Building glare & associated irradiance modeled throughout the day:

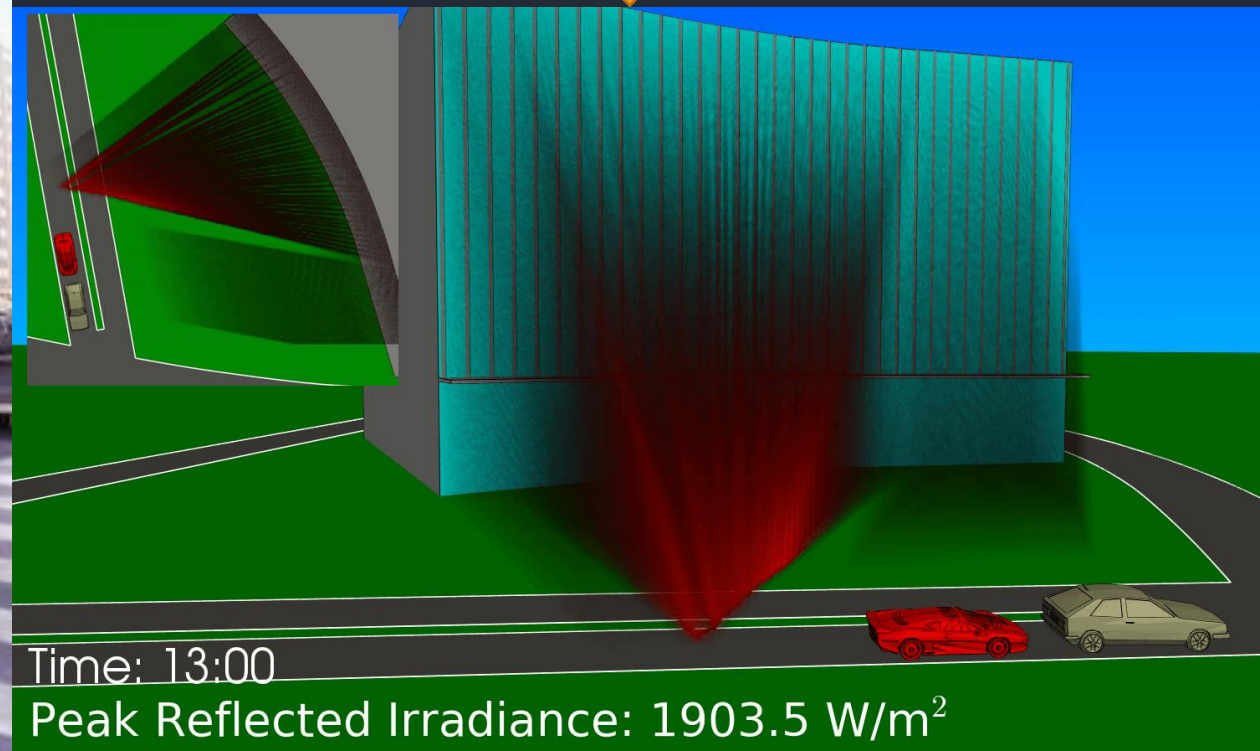


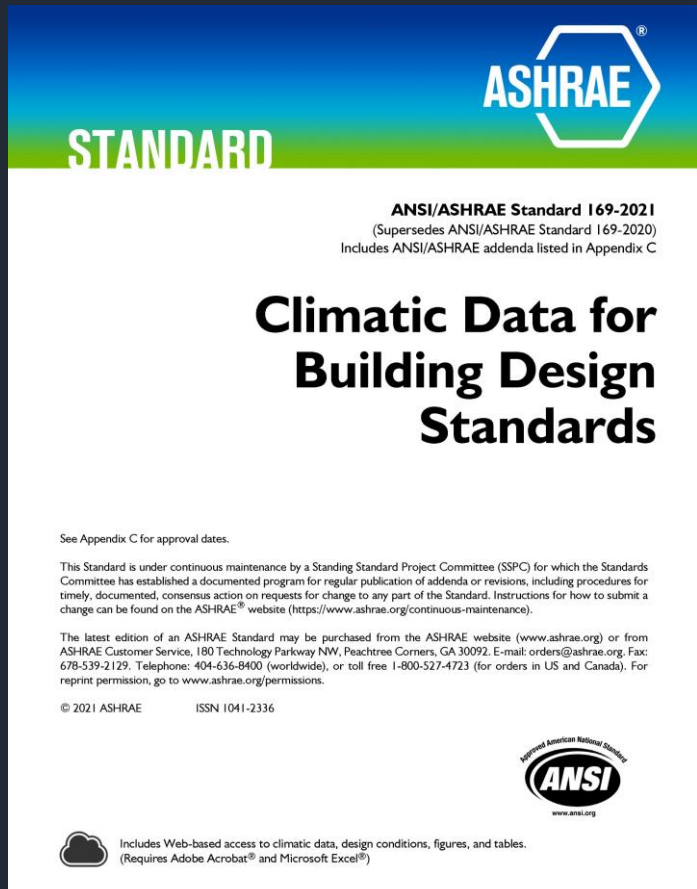
Image & GIF created by RWDI, Inc. Consultants

Sustainable Infrastructure

American Society of Heating, Refrigerating & Air-Conditioning Engineers (ASHRAE)

The POWER Project is working with the ASHRAE professional association to utilize POWER data for the creation their Climatic Design Conditions Report, seeking to make the report more accessible to the global public.

Using MERRA-2 data, POWER creates ASHRAE Building Climate Zone maps for world, as well as “rolling” climate zones from 4-year averages, to illustrate thermal zone changes over time from 1984 through 2021.



ASHRAE

STANDARD

ANSI/ASHRAE Standard 169-2021
(Supersedes ANSI/ASHRAE Standard 169-2020)
Includes ANSI/ASHRAE addenda listed in Appendix C

Climatic Data for Building Design Standards

See Appendix C for approval dates.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. Instructions for how to submit a change can be found on the ASHRAE® website (https://www.ashrae.org/continuous-maintenance).

The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 180 Technology Parkway NW, Peachtree Corners, GA 30092. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

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Approved American National Standard
ANSI
www.ansi.org

Includes Web-based access to climatic data, design conditions, figures, and tables.
(Requires Adobe Acrobat® and Microsoft Excel®)

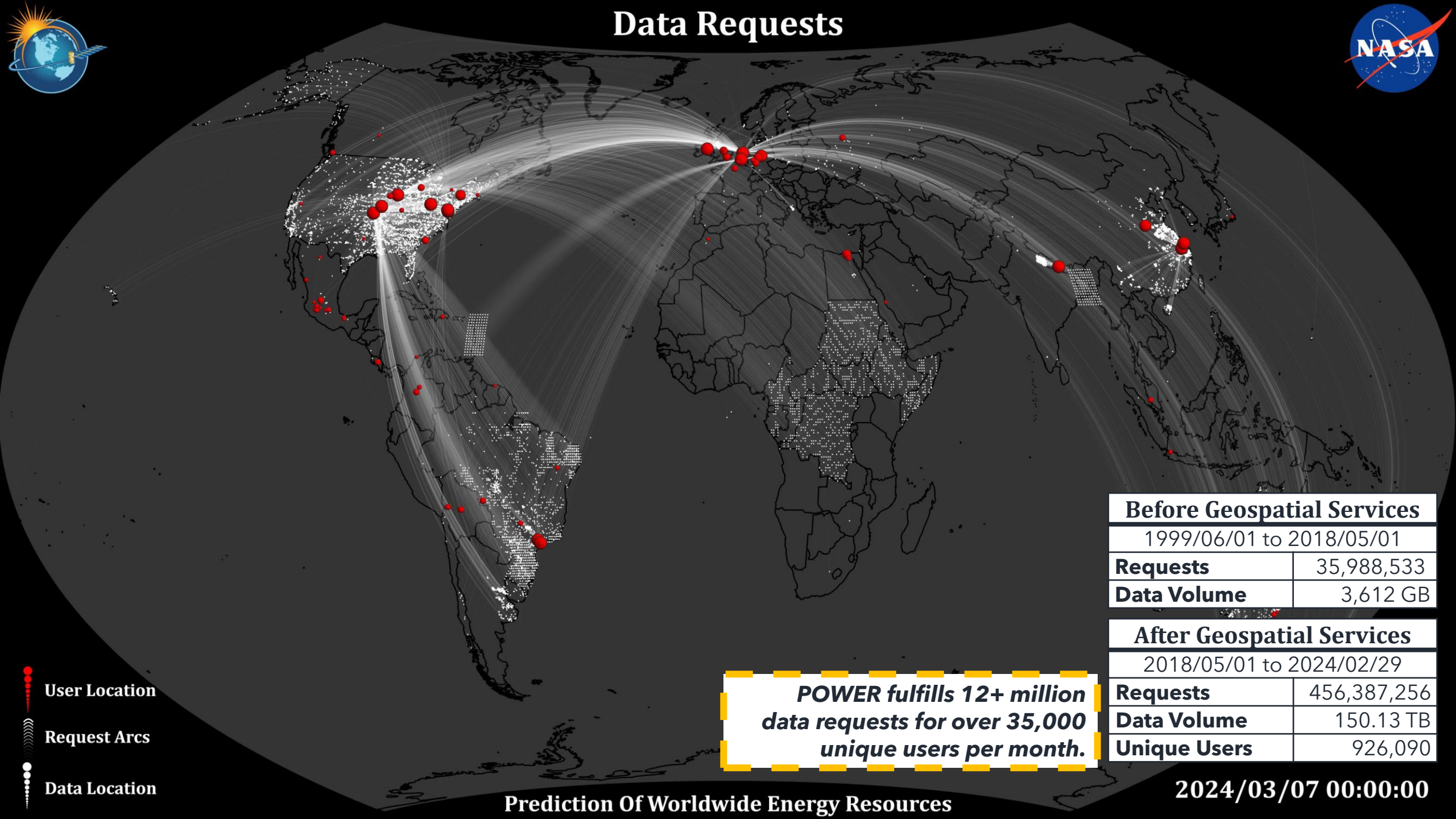
Sustainable Infrastructure

Urban Solar

Urban Solar manufactures solar power systems and LED lightning solutions for transit, transportation, parking lots, pathways, & general illumination applications. Their philosophy is good lightning allows people to feel safe in outdoor spaces.

Urban Solar uses POWER's API to retrieve minimum solar irradiance and to calculate the power generated by solar arrays. They then use this information to manufacture & place solar power systems and LED lightning solutions.

Data Requests



Before Geospatial Services	
1999/06/01 to 2018/05/01	
Requests	35,988,533
Data Volume	3,612 GB

After Geospatial Services	
2018/05/01 to 2024/02/29	
Requests	456,387,256
Data Volume	150.13 TB
Unique Users	926,090

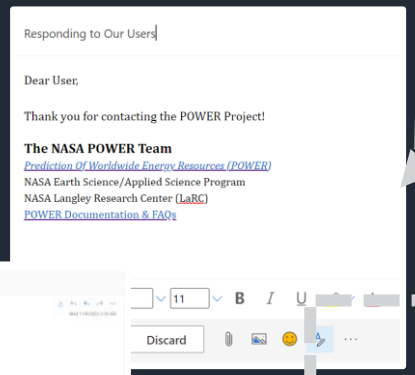
POWER fulfills 12+ million data requests for over 35,000 unique users per month.

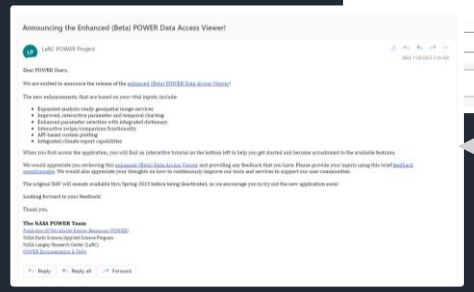
2024/03/07 00:00:00

Prediction Of Worldwide Energy Resources

How does POWER connect with our users?

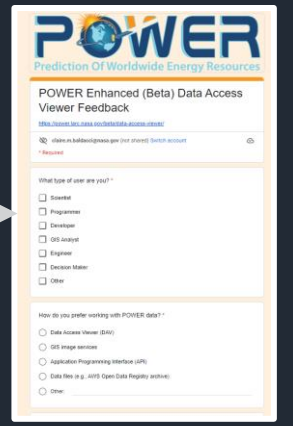
Direct Email Communications
- ➥ Answering User Questions
- ➥ Gathering Feedback on Data & Tools
- ➥ Colleting User Stories & Publications
- ➥ Sharing Project Updates



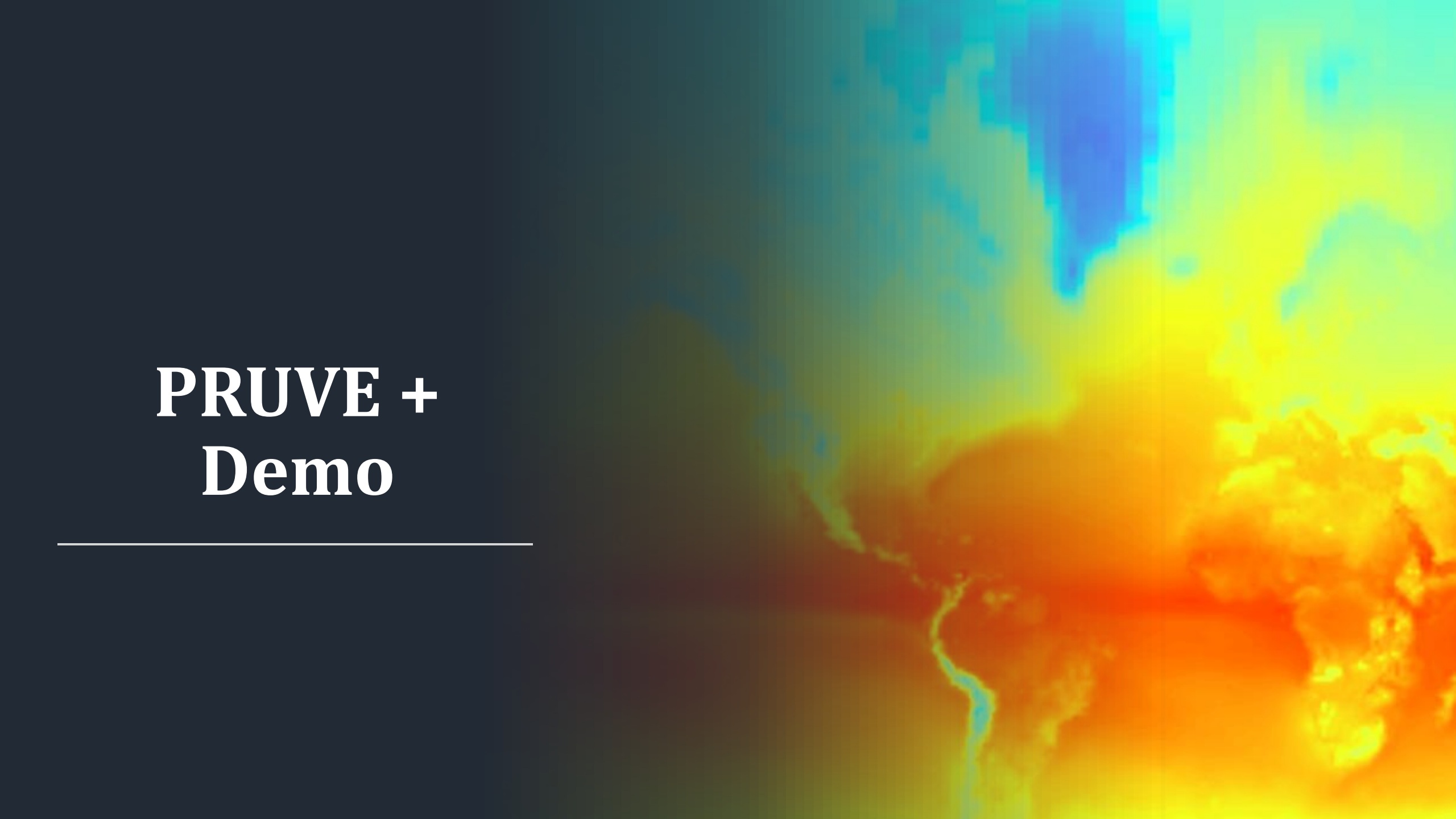


Social Media & Website Posts:
- ➥ NASA Twitter
- ➥ Project Partner Websites
- ➥ Earthdata Learning Resources
- ➥ Agency-wide Announcements

Connecting & Partnering w/ Users:
- ➥ Hosting User-centric Events
- ➥ Presenting at Conferences
- ➥ Creating Meaningful Partnerships
- ➥ Writing Joint Publications
- ➥ Working Event Booths

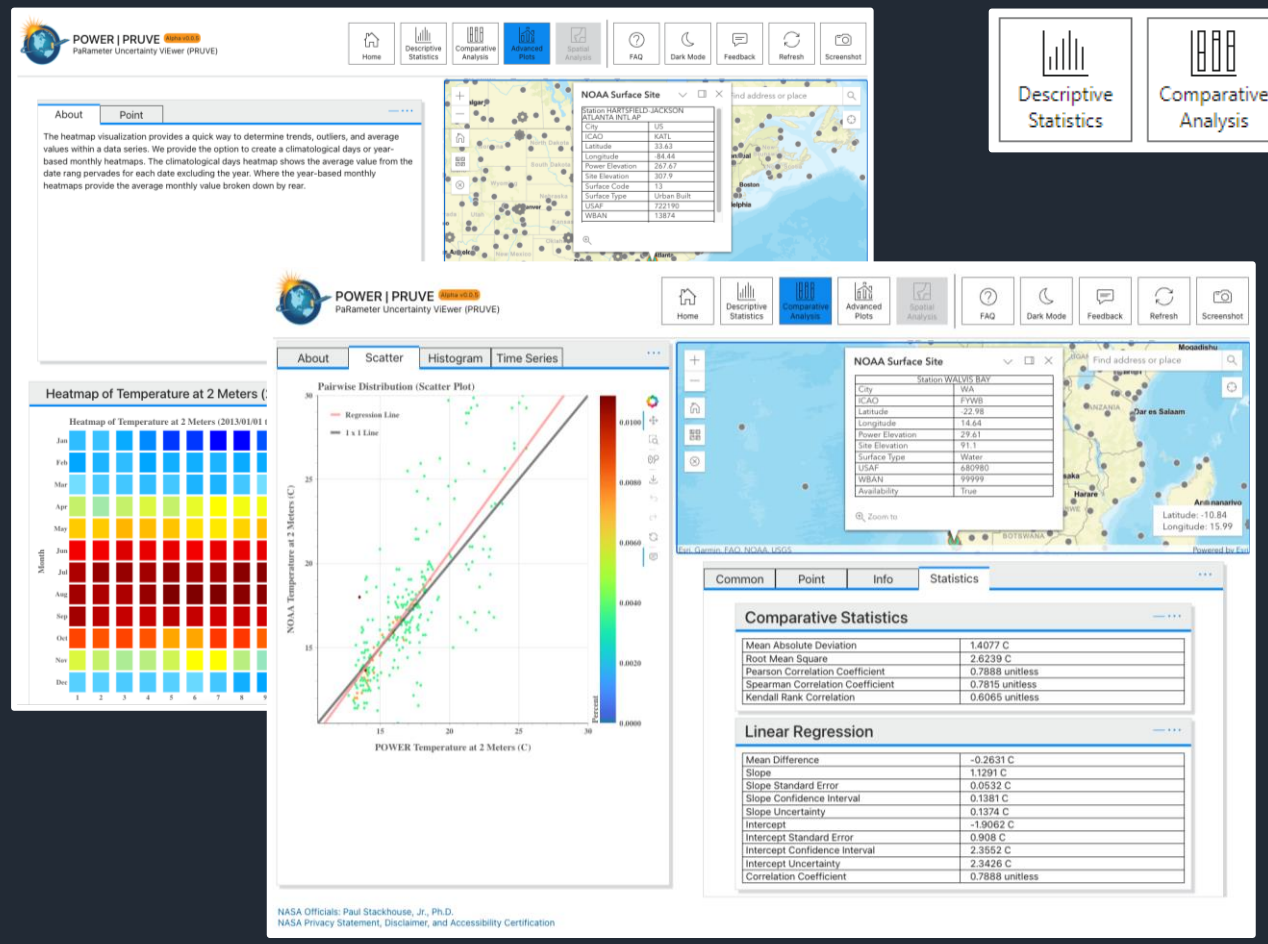


PRUVE + Demo



The PaRameter Uncertainty ViEwer (PRUVE)

The in-development PaRameter Uncertainty ViEwer (PRUVE) application utilizes statistical analysis & visualization capabilities to compare in situ surface site data with POWER's data. The application allows technical & non-technical users to assess data uncertainty within the web framework, lowering the overall level of complexity of assessing data uncertainty.



Solar radiation comparison data from the World Climate Research Programme's (WCRP) Baseline Surface Radiation Network (BSRN)

Meteorology comparison data from the National Oceanic and Atmospheric Administration (NOAA) station reporting systems

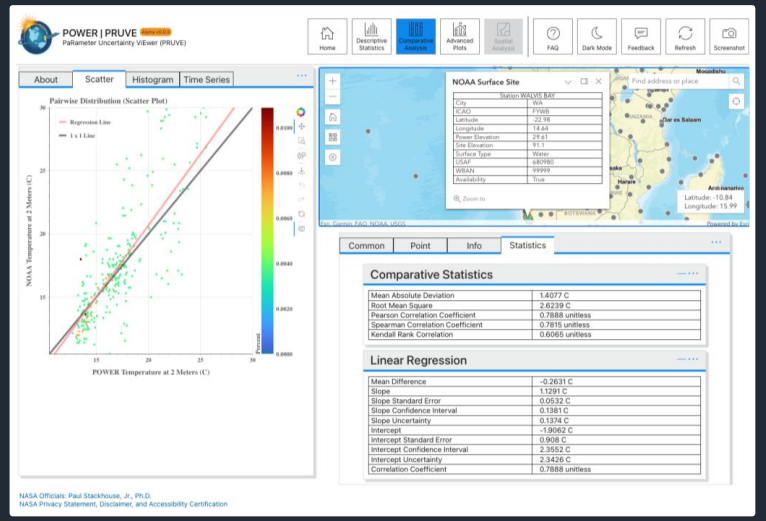
The PaRameter Uncertainty ViEwer (PRUVE)

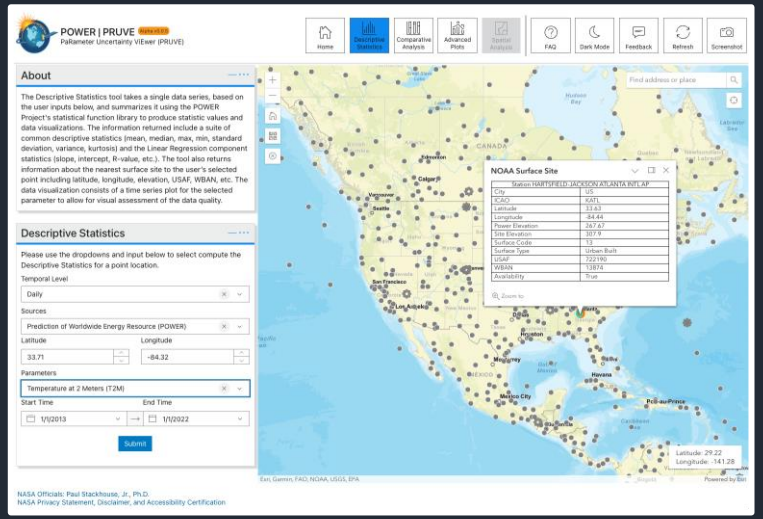
Terminology

- Slope
- Slope Standard Error
- Slope Uncertainty
- Slope Confidence Interval
- Intercept
- Intercept Standard Error
- Intercept Uncertainty
- Intercept Confidence Interval
- Correlation Coefficient
- Coefficient of Determination
- Probability
- Decade Slope
- Decade Uncertainty
- Decade Standard Error
- Weatherhead Uncertainty
- Weatherhead Years To Significance
- Weatherhead Significance
- Standard Deviation
- Standard Deviation (Lower Bound)
- Standard Deviation (Upper Bound)
- Standard Error of the Mean

The tool enables spatial visualizations & specific point-based analysis for single data series and multiple data series. Tool capabilities include:

- Interactive visualizations of meteorological datasets of various chart types
- Text-based statistical information in support of the visualizations
- A resizable interactive map





Descriptive Statistics: BSRN Solar Irradiance

POWER | PRUVE

power.larc.nasa.gov/parameter-uncertainty-viewer/

POWER | PRUVE Beta v0.2.8
PaRameter Uncertainty ViEwer (PRUVE)

Home | Descriptive Statistics | Comparative Analysis | Advanced Plots | FAQ | Settings | Feedback | Tutorial

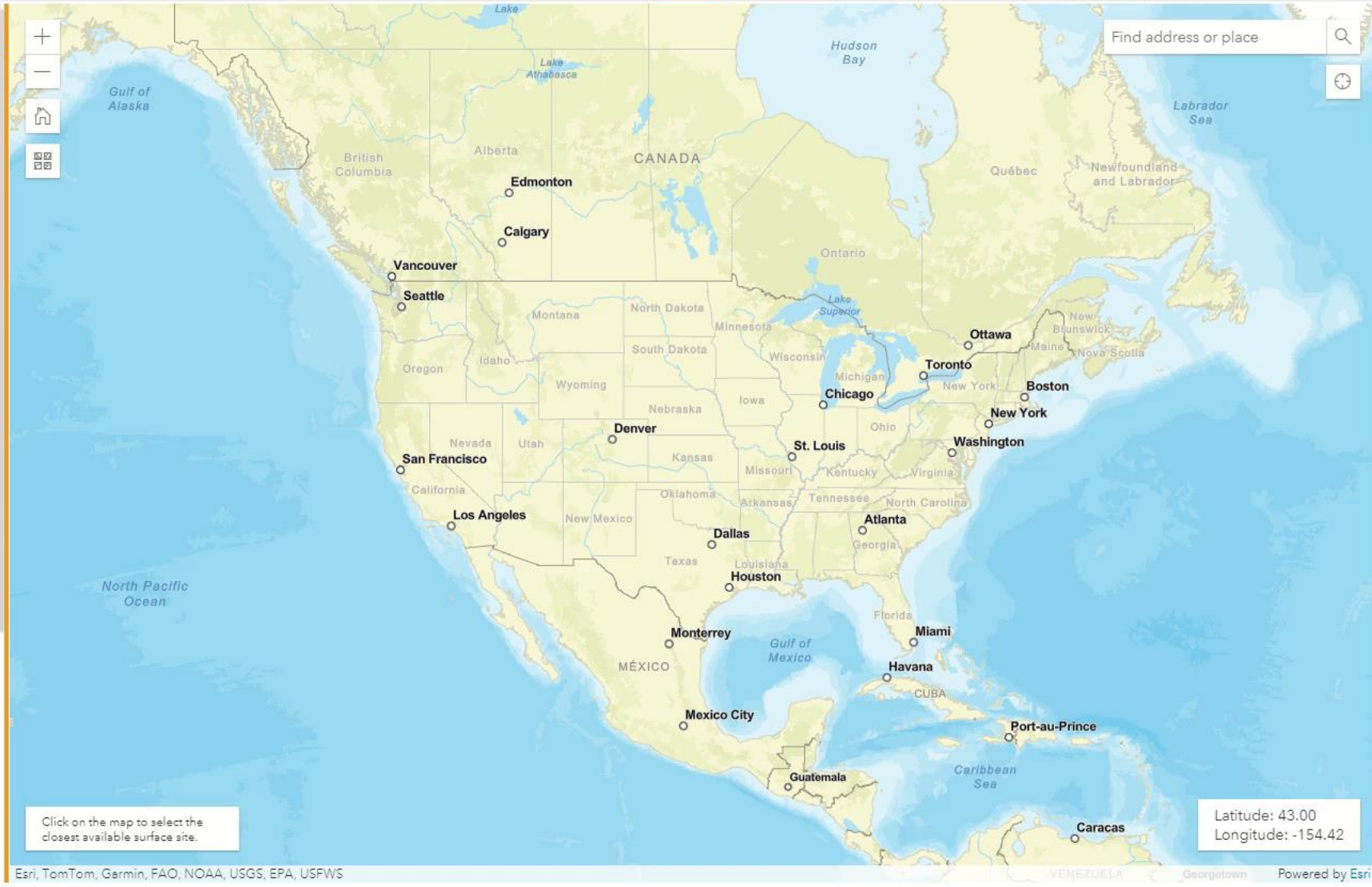
About

The NASA Prediction Of Worldwide Energy Resources (POWER) project's PaRameter Uncertainty ViEwer (PRUVE) application provides data validation capabilities utilizing statistical analysis and visualizations for solar radiation and meteorological data parameters.

Specifically, the PRUVE application uses surface observed site data for comparison with POWER's data. Meteorological data is from National Oceanic and Atmospheric Administration (NOAA) station reporting systems: NOAA Integrated Surface Database (ISD) at hourly temporal resolution and the NOAA Global Surface Summary of the Day (GSOD) at daily temporal resolution. Solar radiation data is from the World Climate Research Programme's (WCRP) Baseline Surface Radiation Network (BSRN) and is available at hourly and daily temporal resolutions. Each data source has different site selection and data quality requirements.

For basic statistical characterization of a single location, navigate to the Descriptive Statistics tab at the top of the page. To compare POWER data to surface observations select the Comparative Analysis tab. Other plotting and statistical capabilities are found under the Advanced Plotting tab.

Note that all validation data are pre-processed and displayed within the application with available data site locations indicated by color coded points on the map. Please follow the prompts for each of the tools. When you select a location, the application determines the surface site closest to your area of interest. All times in the application are represented in standard Coordinated Universal Time (UTC) unless otherwise stated.



NASA Officials: Paul Stackhouse, Jr., Ph.D.
NASA Privacy Statement, Disclaimer, and Accessibility

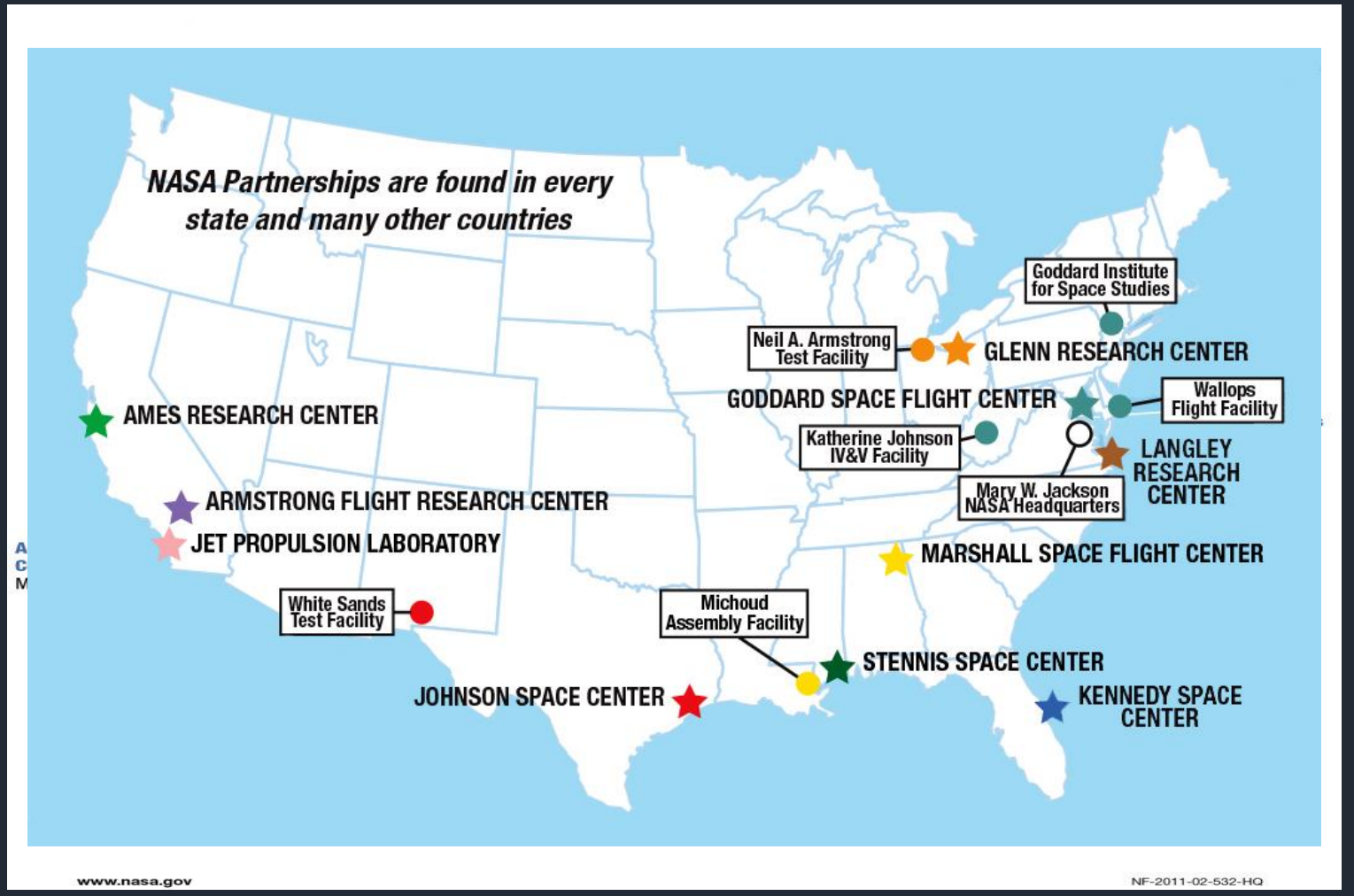
https://power.larc.nasa.gov/parameter-uncertainty-viewer/

Future Conditions

POWER Works With NASA's Infrastructure Office

Climate Adaptation Science Investigators Workgroup (CASI2)

- **Purpose:** To provide **usable projected climate information for decision-makers** within NASA's Office of Strategic Infrastructure (OSI) concerning potential **future meteorological conditions and risks relevant to NASA facilities**.
- **Subgroups**: Energy, Extreme Events, Sea Level Rise and Coastal Flooding, Water Budget, and Wildfires
- **Energy**: Quantify potential changes in total annual and monthly heating and cooling degree days, associated changes in the ASHRAE® thermal zones, and other parameters relevant to building energy systems.



NASA NEX Data: Downscaled Climate Model Data

Purpose

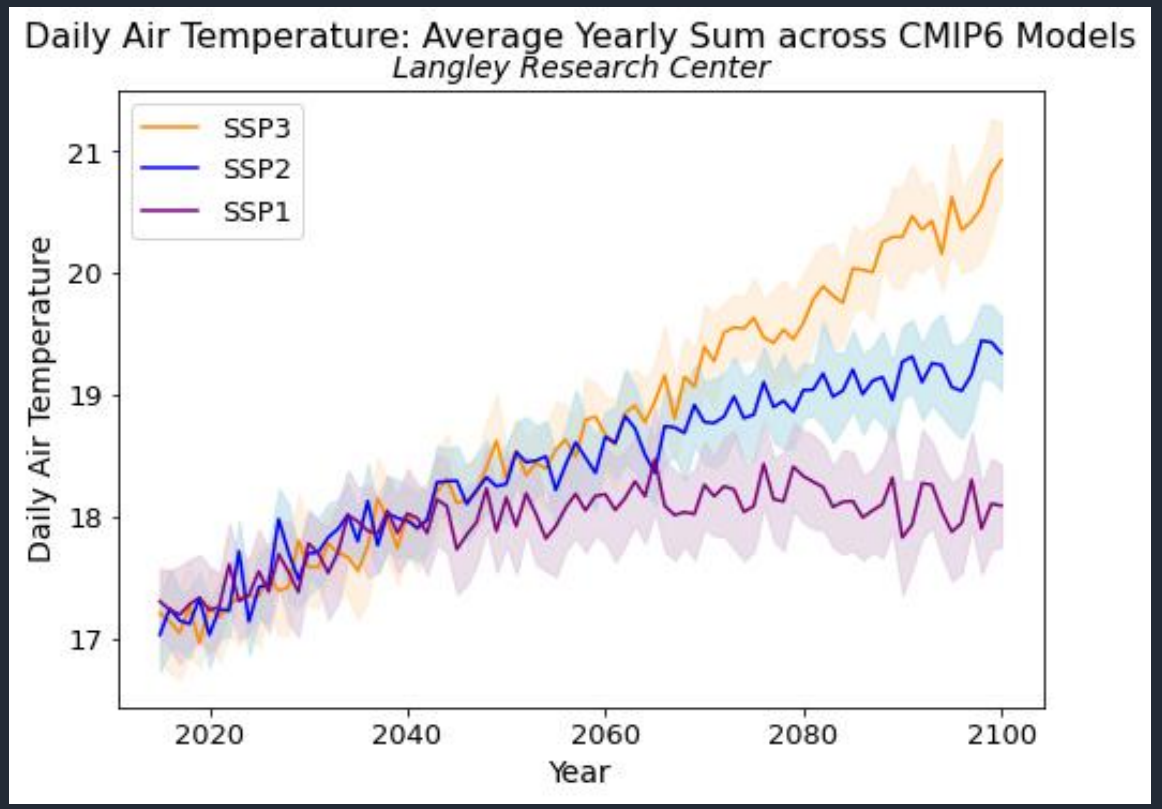
Downscaled data provides more information across a regional area than coarse raw climate model output

Characteristics

- NASA Exchange (NEX) Global Downscaled Data Product (Thrasher et al., 2023)
- Spatial and Time Coverage: Daily data, ¼°x¼°, 60°S-90°N, 180°W-180°E; 1950-2100
- Ensemble average: 22 models (removed spurious "hot" models; Hausfather et al., 2022)
- Variables available: 9 meteorological variables
- Bias corrected with Princeton (GFDL) climatology (Sheffield et al., 2006)
- 3 Shared Socio-economic Pathways (SSP)

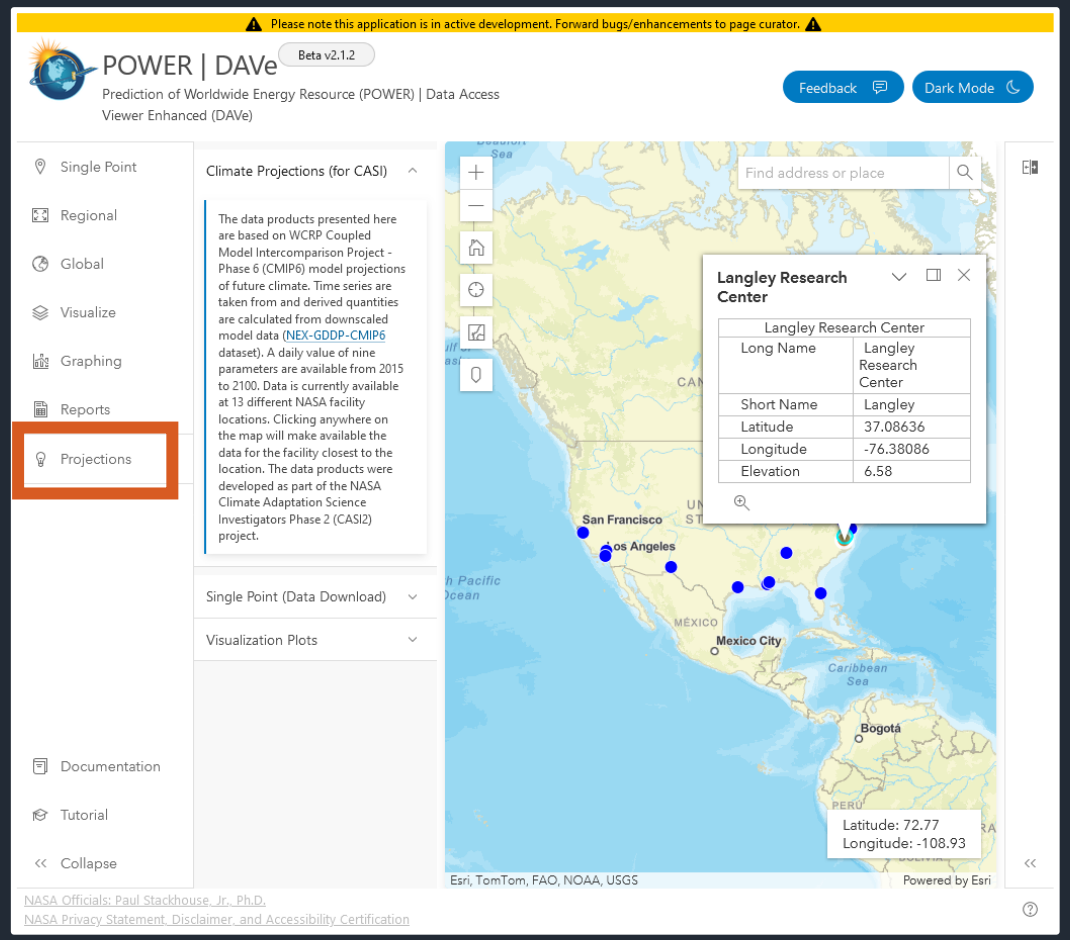
Emissions Scenarios	Description
Low (SSP1_26)	Sustainability – Taking the Green Road
Medium (SSP2_45)	Middle of the Road
High (SSP3_70)	Regional Rivalry - A Rocky Road

Class	Parameter
Temperature	Mean, Min, Max
Humidity	Specific, Relative
Wind	Wind speed
Precipitation	Water amount
Radiative	Solar, thermal infrared

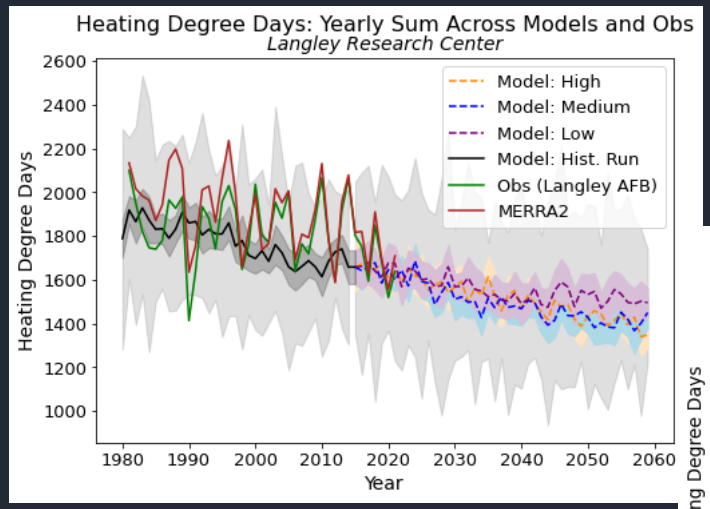


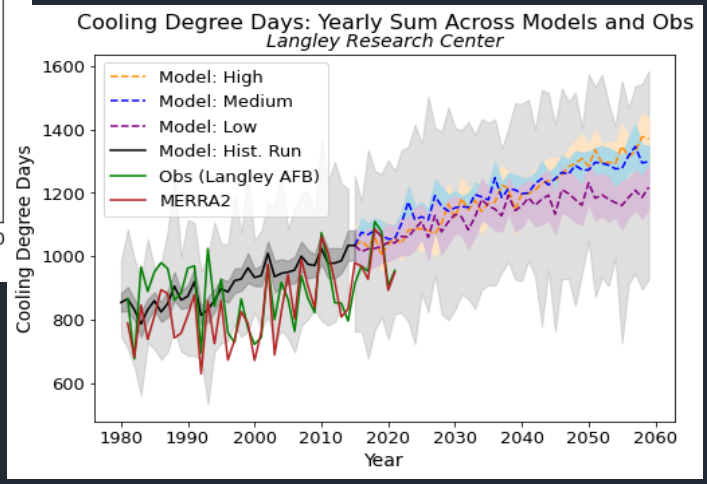
NASA POWER Climate Risk Information Services

New Climate Projections data download & visualizations, developed as a part of the NASA Climate Adaptation Science Investigators Program.

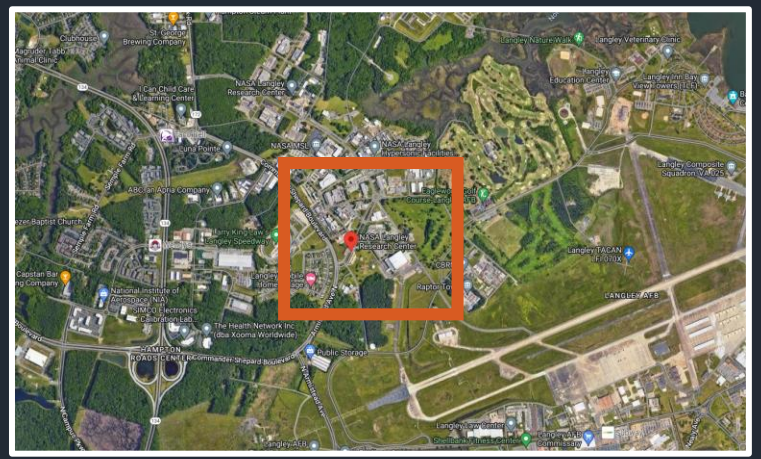


< *Heating Degree Days*



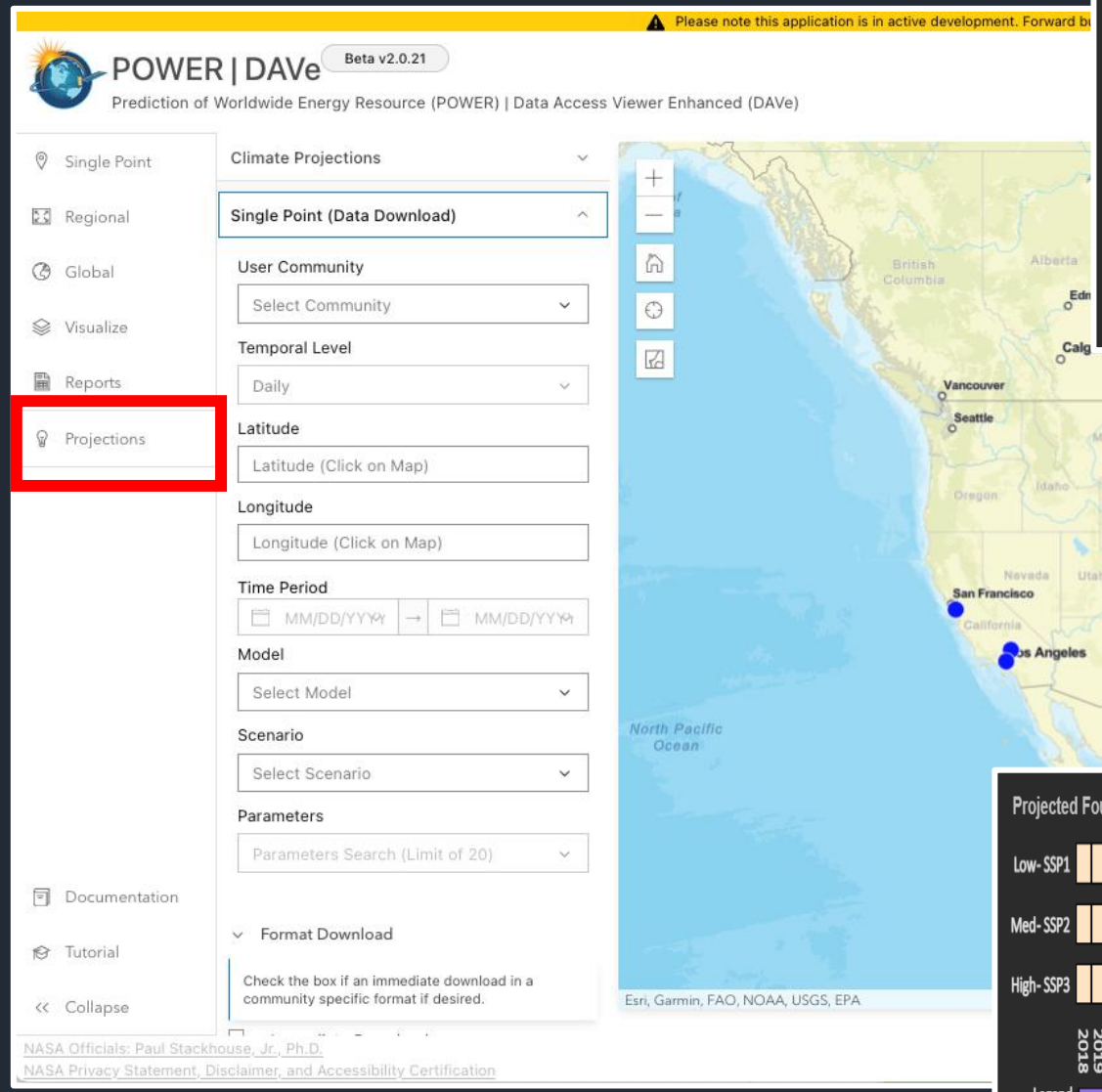


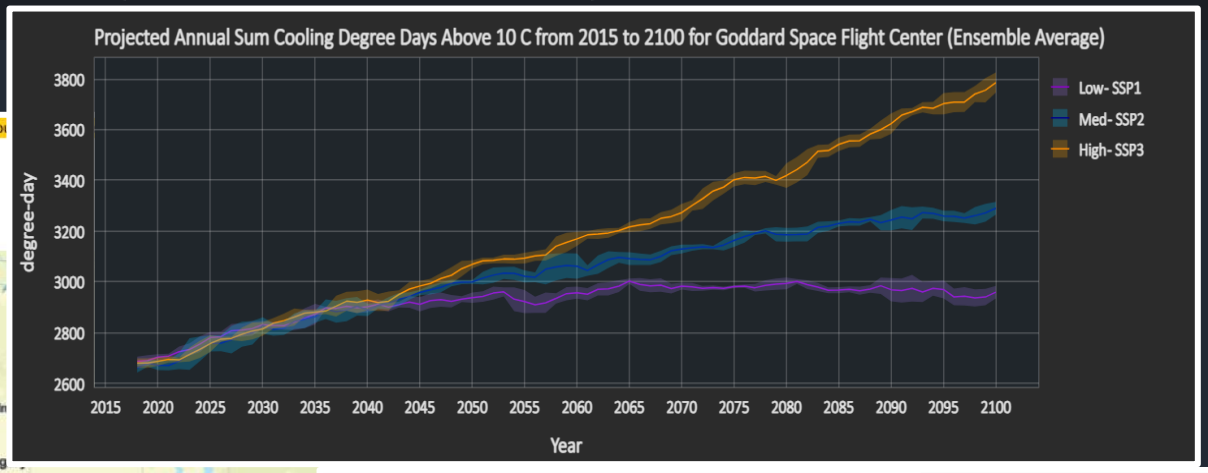
Cooling Degree Days >

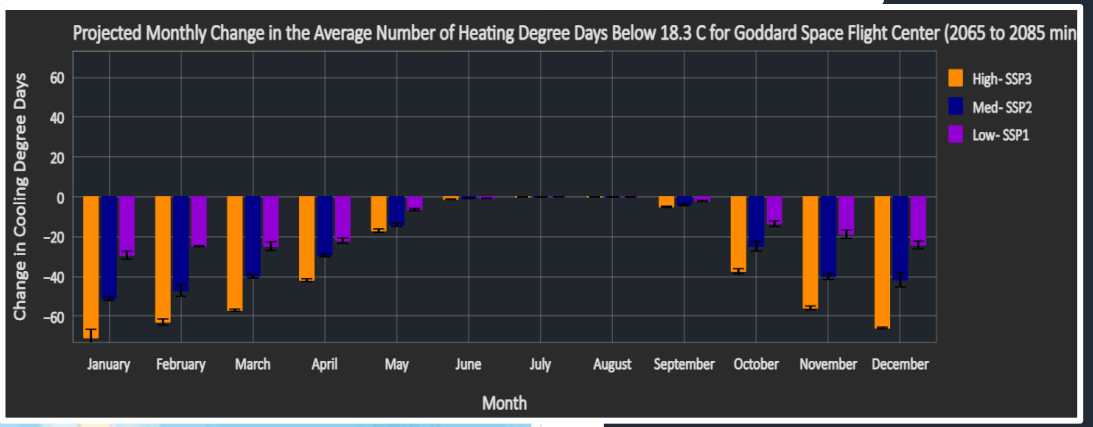


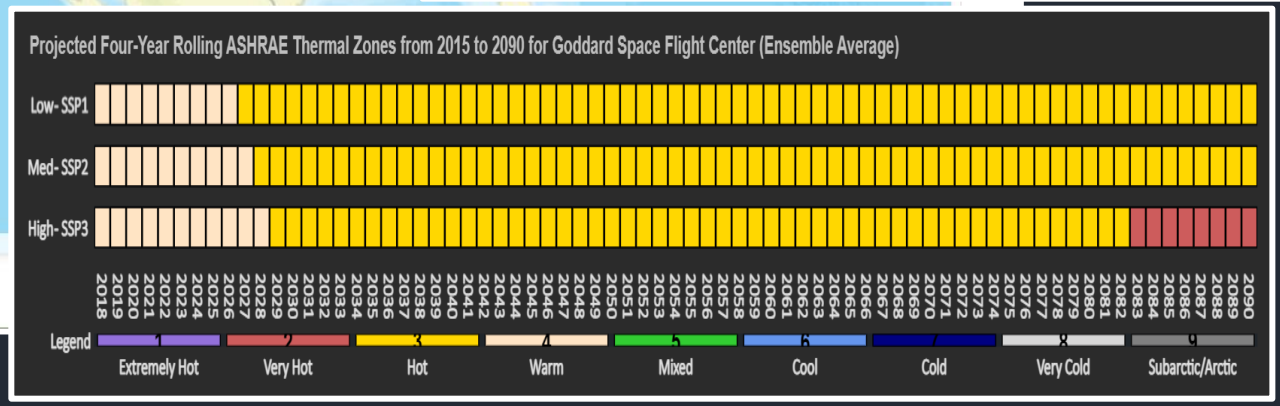
Seeking to provide data products for communities around NASA centers and then **expand projection spatial coverage of data products to a global extent**

CASI-2 Product Services (via POWER)









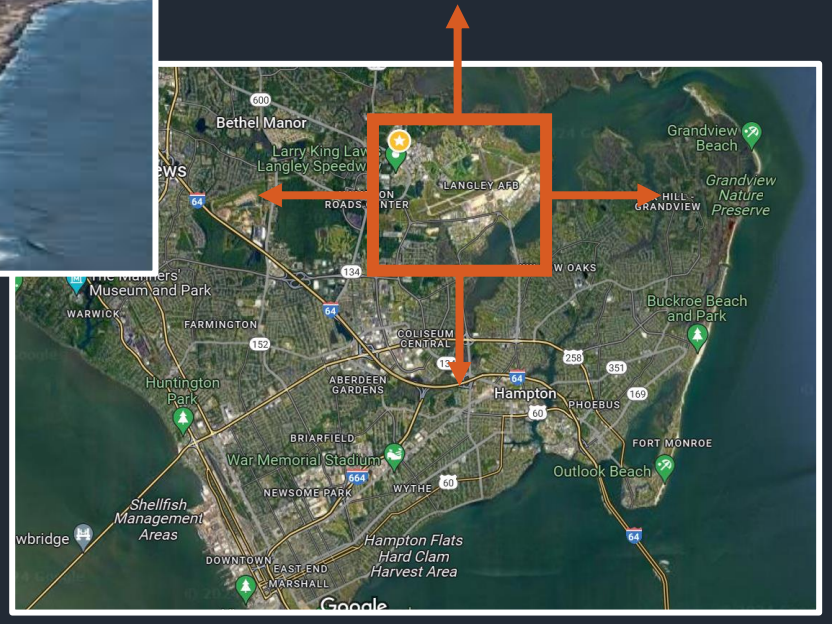
(https://power.larc.nasa.gov)

Center	Thermal Zone Change?	Thermal Zone Change	When in High Emissions Scenario?	When in Medium Emissions Scenario?	When in Low Emissions Scenario?
Glenn	Yes	5-->4	After 2030	After 2030	After 2030
Johnson	Yes	2-->1	After 2045	After 2091	No change
Langley	Yes	3-->2	After 2060	No change	No change
Goddard	Yes	4 ->2	After 2028 (to 3) After 2085 (to 2)	After 2028 (to 3)	After 2028 (to 3)

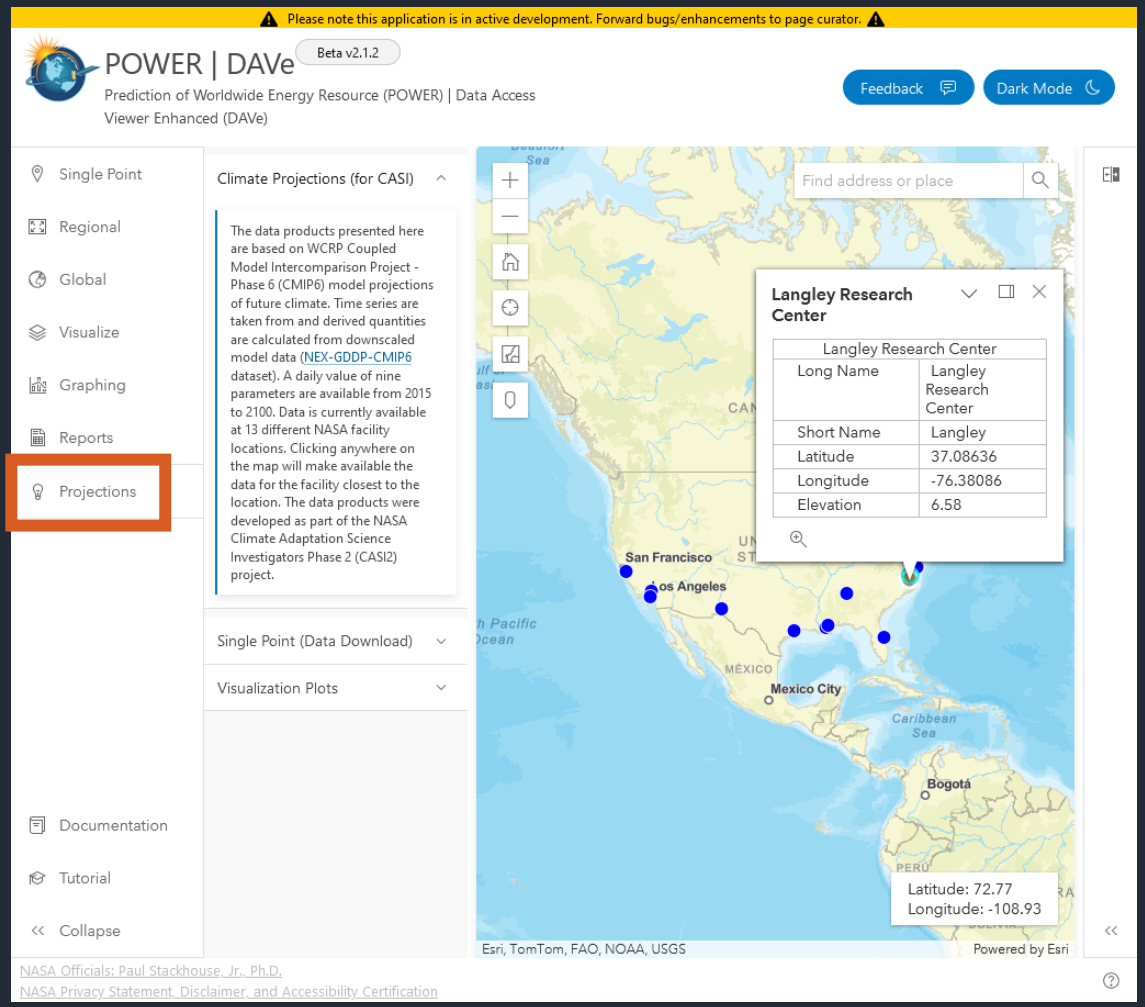
Use of data product: Estimate the change in the thermal climate zone

NASA POWER Climate Data Services – What's Next?

Integrate real-world NASA buildings into RETScreen® analysis

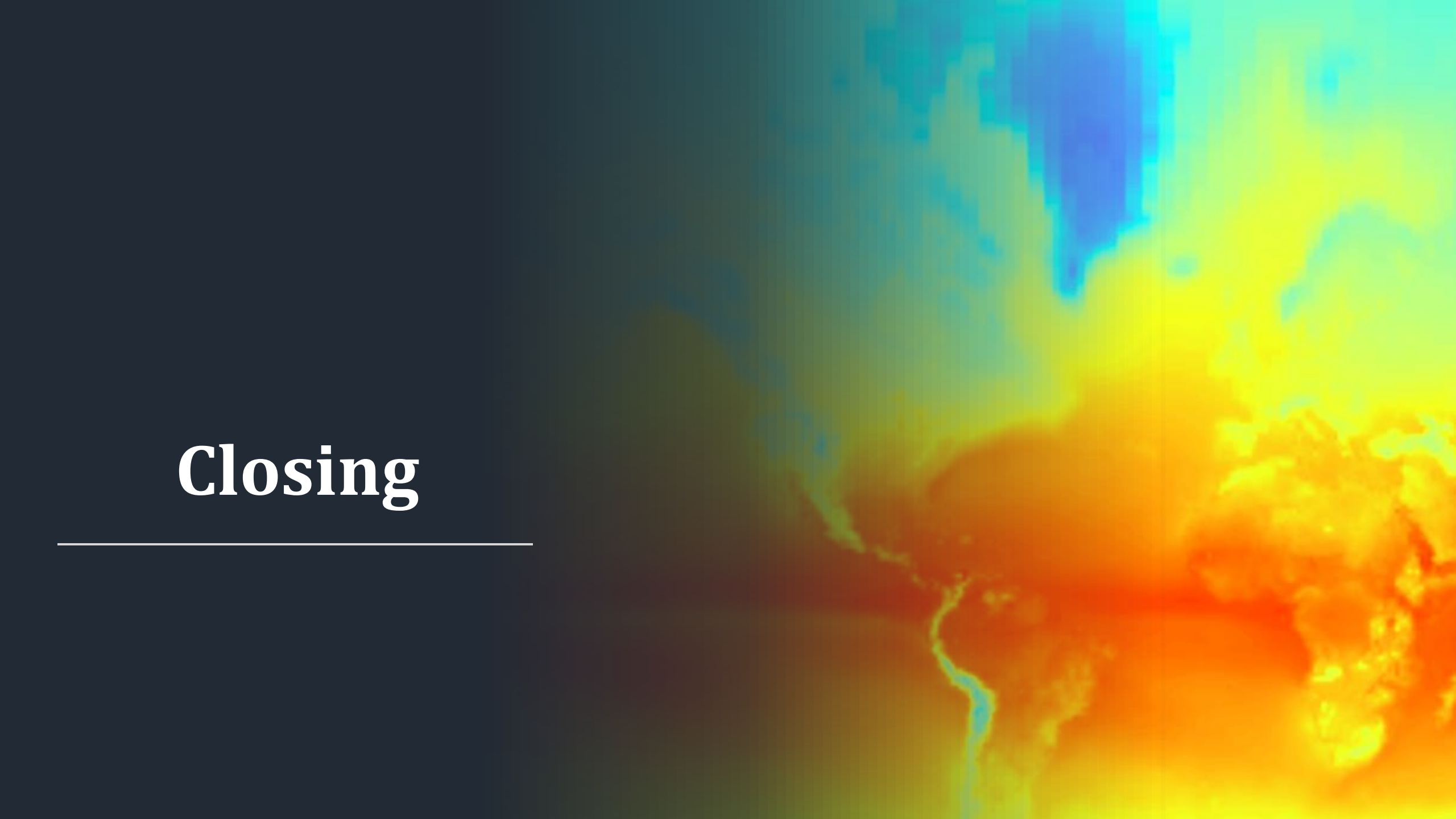


Provide data products for communities around NASA centers

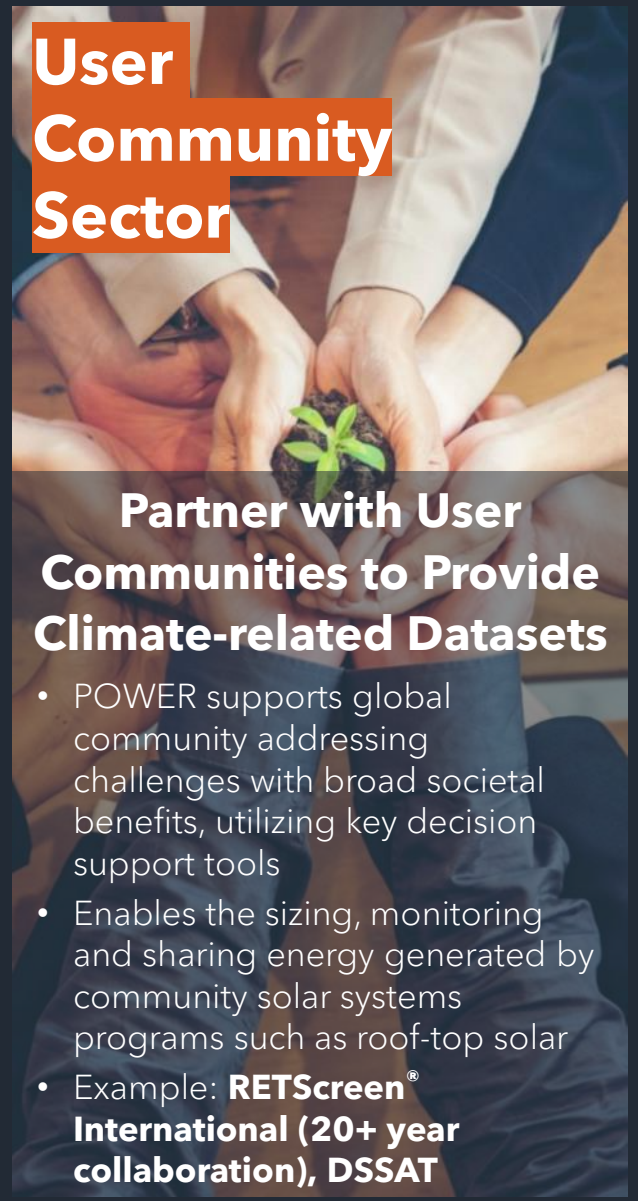


Expand projection spatial coverage of data products (regional/global)

Closing



Who does POWER collaborate and/or partner with?



User Community Sector

Partner with User Communities to Provide Climate-related Datasets

- POWER supports global community addressing challenges with broad societal benefits, utilizing key decision support tools
- Enables the sizing, monitoring and sharing energy generated by community solar systems programs such as roof-top solar
- Example: **RETScreen® International (20+ year collaboration), DSSAT**

Private Sector

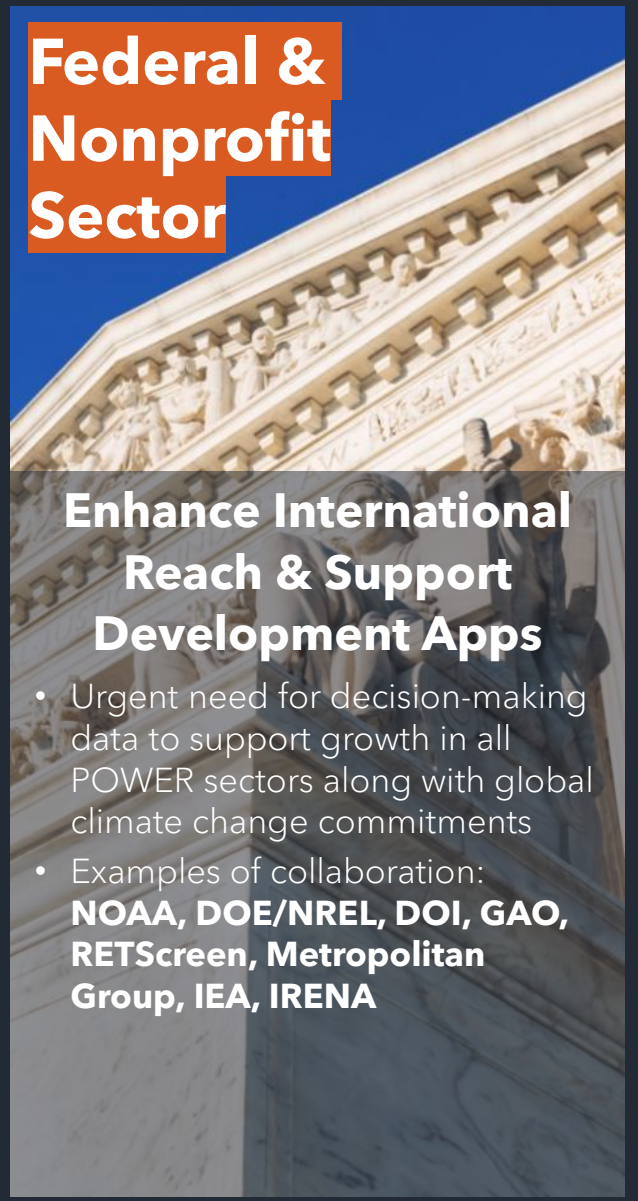
Partner with Businesses to Improve Energy Efficiency & Resources

- Growing demand for clean energy investments & requirements for corporate risk disclosure
- Enable/empower small businesses to corporate investors to conduct economic efficiency analyses (improve the bottom line & reduce emissions)
- Example: **ASHRAE, Consumer First Renewables, Saildrone, etc**

Education Sector

Partner with Educators to Build Earth Observation Literacy

- Growing need for improved EO educational resources; projected 8% growth in job market by 2029
- POWER provides a free, single-source of multiple datasets & variables to teach EO best practices for a wide-range of project types
- Examples: **U. of Wisc, National Wildlife Federation, My NASA Data on-line, U. FL, U. Utah**



Federal & Nonprofit Sector

Enhance International Reach & Support Development Apps

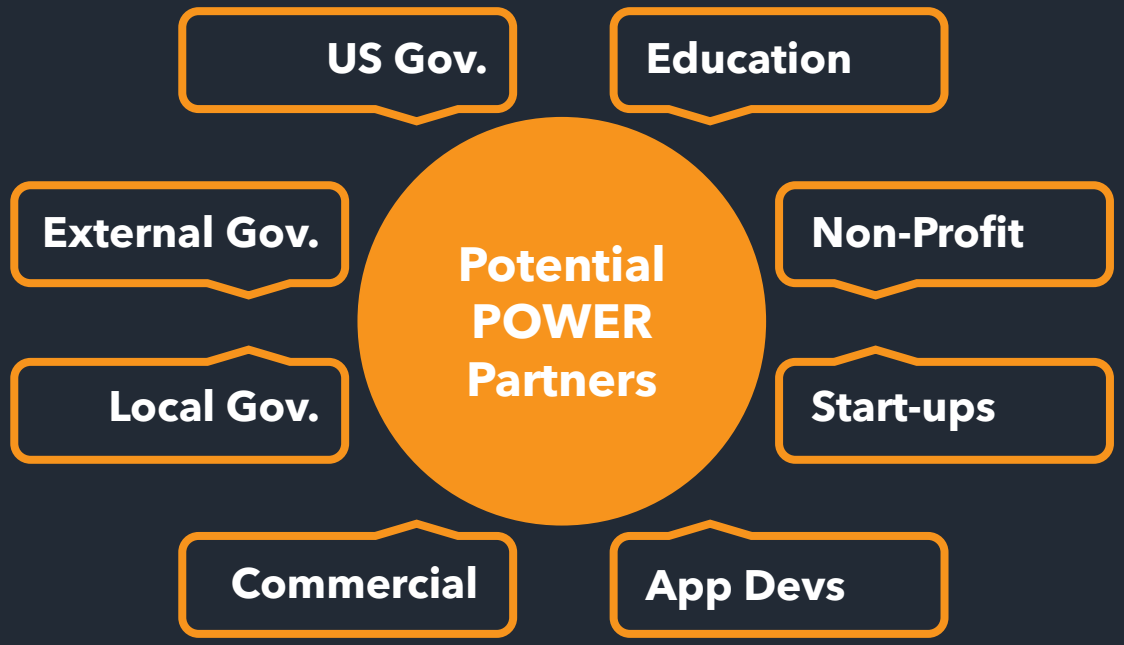
- Urgent need for decision-making data to support growth in all POWER sectors along with global climate change commitments
- Examples of collaboration: **NOAA, DOE/NREL, DOI, GAO, RETScreen, Metropolitan Group, IEA, IRENA**

Want to Get Involved with POWER?

The team loves to hear feedback on POWER's data & applications. You can reach out to the POWER team direct via our email: larc-power-project@mail.nasa.gov

SCAN ME

This QR code leads to POWER's "Contact Us" information, as seen below.



The POWER Project likes to showcase presentations, papers, & projects that have used POWER data & tools on our website & within our presentations.

National Aeronautics and Space Administration

Join Us in POWERing the Future of Energy, Agroclimatology, & Sustainable Infrastructure

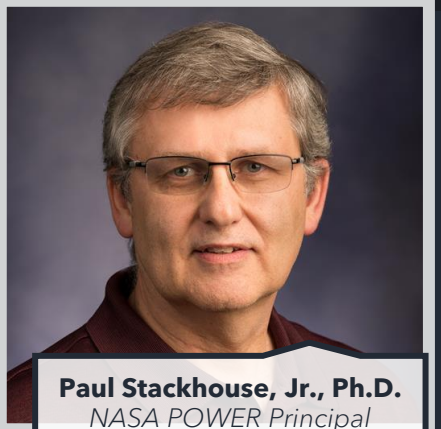
Website: https://power.larc.nasa.gov **| Email:** larc-power-project@mail.nasa.gov

POWER
Prediction Of Worldwide Energy Resources

Prediction Of Worldwide Energy Resources (POWER) | NASA Langley Research Center | NASA Applied Sciences Program

Monthly snapshot of user locations connected to data request locations

The POWER Team



Paul Stackhouse, Jr., Ph.D.
NASA POWER Principal Investigator

Falguni Patadia, Ph.D.
NASA POWER Co-Principal Investigator

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- Research & Validation
- Communications, Marketing, & GIS
- Technical & Web Development
- Strategic Planning

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Senior Research Scientist

Colleen Mikovitz
Research Scientist

Neha Khadka
Research Scientist

Brad Hegyi, Ph.D
Data Analyst for Climate Services

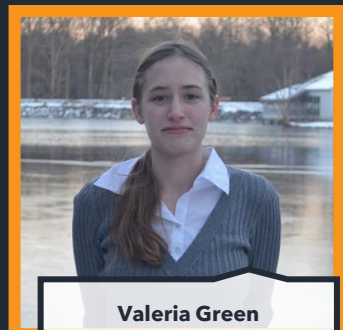
Amanda Merritt
Strategic Communications Specialist

Claire Baldacci
Geospatial Data Scientist & Energy Analyst

Zoe Waring
Scientific & Technical Writer

Bradley Macpherson
Geospatial & Technology Developer

Christopher Higham
Geospatial & Technology Developer



Valeria Green
Font End Software Engineer

Benjamin Landes
Web Developer

Nikhil Aluru
Data Scientist

A. Jason Barnett
Geospatial & Technology Developer