

## Introduction

NASA's Prediction of Worldwide Energy Resource (POWER) project facilitates the use of NASA Earth Science data holdings within the energy, agricultural, and architectural industries. POWER packages solar and meteorological data at various temporal levels from several NASA projects in a user-friendly GIS-enabled web services system (<https://power.larc.nasa.gov>).

Among other possible formats, data users can request POWER data in a column formatted DSSAT ASCII format by entering single site-specific coordinates or from an area by entering the appropriate area coordinate bounds.

We present here recent evaluations of the POWER meteorological data through comparisons with global surface site measurements. While most meteorological parameters are taken from the NASA Modern Era Retrospective-analysis for Research and Applications (MERRA-2) data set, an alternate precipitation source from Integrated Multi-satellite Retrievals for GPM (IMERG) is available and included in this evaluation.

## Data Sources - Meteorological

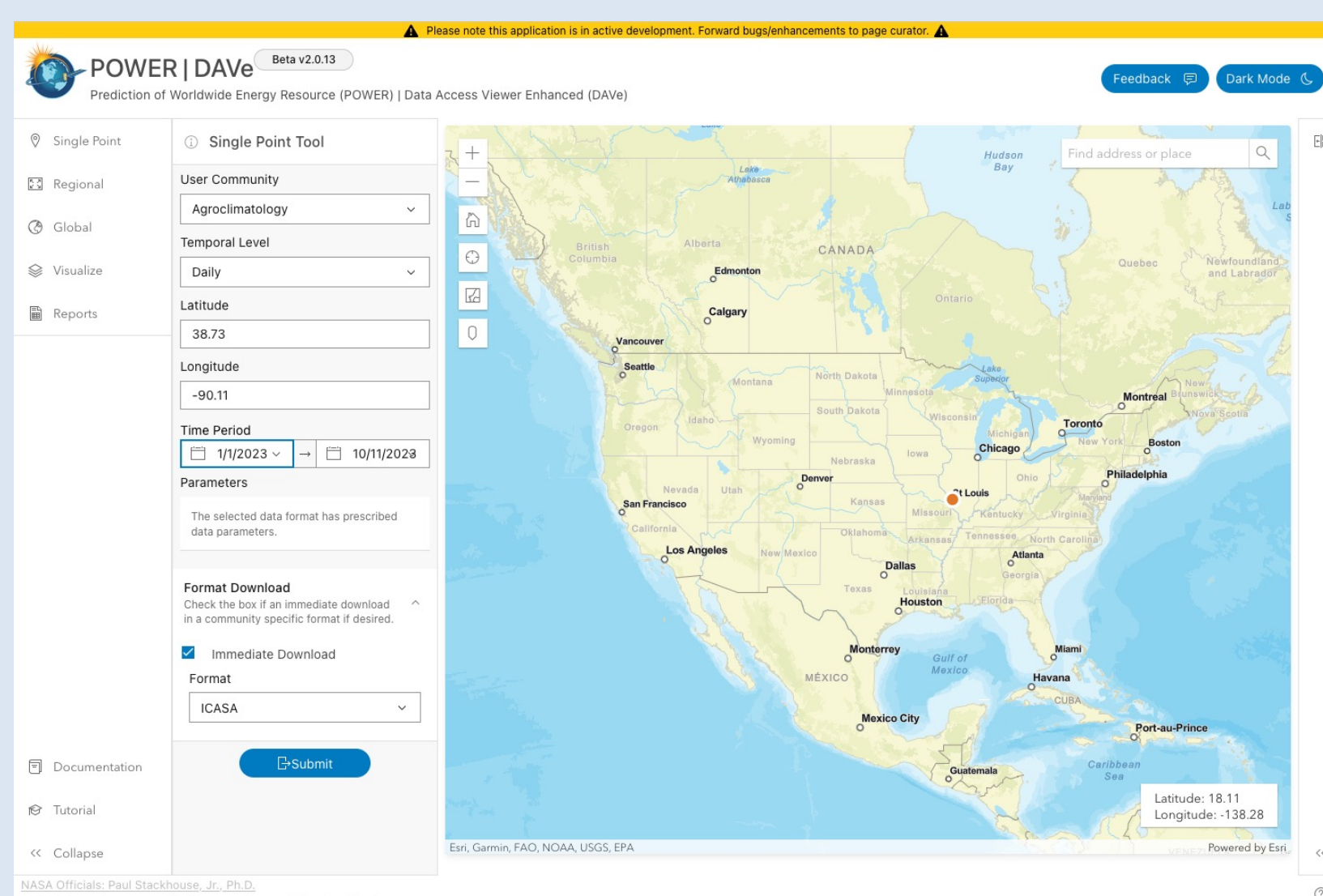
- MERRA-2
- NASA's GMAO MERRA-2 Reanalysis data set provides most meteorological parameters hosted by POWER.
- Original spatial resolution is 1/2° latitude x 5/8° longitude, current POWER version retains this resolution.
- Available daily and higher from 1 January 1981, hourly from 1 January 2001.
- Selected references: Rienecker et al. 2008, Gelaro et al. 2017

- IMERG
- NASA's Global Precipitation Measurement (GPM) Integrated Multi-satellite Retrievals for GPM is an alternative precipitation data set for POWER users.
- Final and Late runs
- Finer spatial resolution than MERRA-2 at 1/10° x 1/10°
- Available daily from 1 January 2001
- Huffman et al. 2019

- NOAA GSOD/ISD
- Surface site observations are from the NOAA National Centers for Environmental Information (NCEI).
- Hourly surface observations are available through the Integrated Surface Database (ISD).
- Daily observations are from the Global Summary Of the Day (GSOD).
- Smith et al., 2011

## Getting Data from POWER

- 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 (DAV): 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. The tool also offers interactive plotting and map visualization capabilities.
- 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.
- Link to the new DAV: <https://power.larc.nasa.gov/beta/data-access-viewer/>



## Data Output Formats

Decision Support System for Agrotechnology Transfer (DSSAT) ready, International Consortium for Agricultural Systems Applications (ICASA) Version 2 data standard (White, et al., 2013)

WEATHER DATA: NASA										
! T2M	Temperature at 2 Meters (C)									
! T2Mn	Temperature at 2 Meters Minimum (C)									
! T2Mx	Temperature at 2 Meters Maximum (C)									
! TDew	Dew/Frost Point at 2 Meters (C)									
! RH2M	Relative Humidity at 2 Meters (%)									
! RAIN	Precipitation Corrected (mm/day)									
! WIND	Wind Speed at 2 Meters (m/s)									
! SRAD	All Sky Surface Shortwave Downward Irradiance (MJ/m <sup>2</sup> /day)									
! MELEV	Mean elevation for source NASA/POWER data tile (0.5 x 0.625 grid cell) = 152.79m									
@ INSI	WTHLAT	WTHLONG	WELEV	TAV	AMP	REFHT	WNDDHT			
	38.73	-90.11	152.79	10.1	22.6	2	2			
@ DATE	T2M	T2Mn	T2Mx	TDew	RH2M	RAIN	WIND	SRAD		
20230801	8.6	4.7	16.8	8.5	93.9	0.1	1.6	8.9		
20230802	11.8	7.2	16.6	12.8	96.8	13.7	1.7	2.8		
20230803	15.3	6.8	20.9	12.6	84.5	11.4	3.7	7.1		
20230804	3.0	-0.5	7.2	-1.3	74.4	0.0	2.6	4.4		
20230805	0.7	-2.6	4.4	-2.3	62.2	0.0	2.7	4.9		

Other formats available: CSV JSON ASCII GeoJSON NETCDF

## ICASA

## Data of Interest to Agriculture

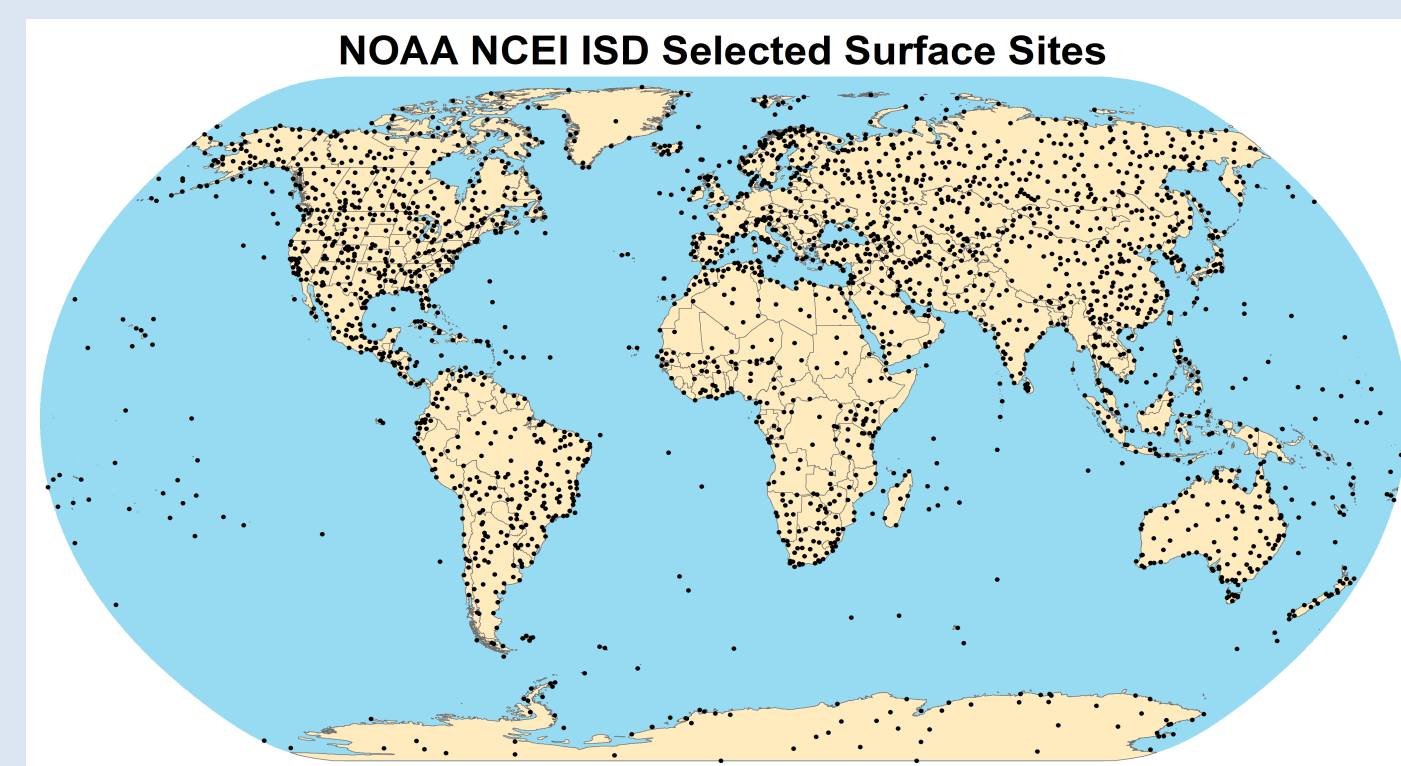
- Temperature
- Humidity
- Wind Speed & Direction
- Precipitation
- Surface, Profile, & Root Zone Soil Wetness

## Future POWER Data Planned for 2024

- IMERG Version 7 – updated precipitation
- Soil Moisture Active Passive (SMAP) – new source of soil moisture

## Surface Site Selection

- Based on hourly data from ISD
- Exclude data based on quality control flags included with data
- Using only top-of-hour observations
- Using sites with 25% hourly availability per year – allows for data poor regions to be represented
- Limit the number per MERRA-2 grid box by allowing only one IGBP surface type per grid box
- Use the same resulting sites for daily validation from GSOD



## Analysis Methods

- Statistical comparisons: Bias (mean difference), absolute bias (mean absolute difference), root mean square (RMS) difference, correlation, standard deviation, and mean absolute deviation
- Map visualizations
- Taylor diagrams: Normalizes statistics for multiple parameters to be assessed together
- Precipitation Contingency

## Questions?

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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](mailto:larc-power-project@mail.nasa.gov) (or scan QR code)



## Surface Site Validation Statistics Summary

Hourly covering period from 1 January 2001 through 31 December 2020

Field	Site mean	Bias	Abs. bias	RMS	R <sup>2</sup>	Std. dev	Mean abs dev	N (millions)
Temp. 2 m	12.8	-0.52	2.24	2.93	0.33	2.88	2.20	163.1
Dewpoint	6.71	0.06	2.19	2.96	0.28	2.96	2.19	156.7
Surface Pressure	996.80	0.30	1.13	1.82	0.72	1.79	1.14	100.0
Wind Speed 10 m	3.58	0.45	1.65	2.17	0.24	2.12	1.65	161.3

- Temperature parameters and surface pressure within 5% absolute bias
- Wind speed not represented as well as temperature, more variable field
- Surface pressure is directly ingested into MERRA-2, therefore should be highly correlated
- Surface pressure for validation is adjusted for difference in MERRA-2 grid box elevation and surface site elevation

Daily covering period from 1 January 1981 through 31 December 2020

Field	Site mean	Bias	Abs. bias	RMS	R <sup>2</sup>	Std. dev	Mean abs dev	N (millions)
Temp. 2 m	11.95	-0.53	1.58	2.10	0.97	2.04	1.54	5.6
Temp. 2 m daily max	17.73	-1.23	2.42	3.10	0.87	2.84	2.18	22.6
Temp. 2 m daily min	7.63	0.32	2.41	3.15	0.87	3.13	2.40	22.6
Dewpoint	6.15	0.21	1.74	2.34	0.95	2.33	1.73	5.2
Precipitation	1.38	0.55	1.63	3.69	0.39	3.64	1.76	21.3
Surface Pressure	973.63	0.05	1.25	2.87	0.99	2.87	1.25	2.2
Wind Speed 10 m	3.65	0.33	1.12	1.45	0.60	1.41	1.09	5.2
Wind Speed 10 m max	6.01	-0.27	1.94	2.49	0.43	2.48	1.93	21.9

- Most sites report daily high and low temperatures not mean temperature
- Similar bias, RMS and std. dev. for mean 2 m temperature, dewpoint and mean 10 m wind speed as hourly observations
- Higher correlations than hourly for similar parameters
- Smaller MERRA-2 daily 2 m temperature than observed; daily max is under-predicted, daily min is slightly over-predicted.

## Precipitation in Depth

Because precipitation is a highly variable event in both space and time, a contingency table analysis allows for an in-depth view of events and non-events.

- MERRA-2 and GSOD agree on events 75% of the data days
- When both report precipitation, agreement on amount within margin of reporting error happens 15% of the time, mostly for low precipitation amounts

IMERG and MERRA-2 are compared for accumulations by week and month for precipitation events.

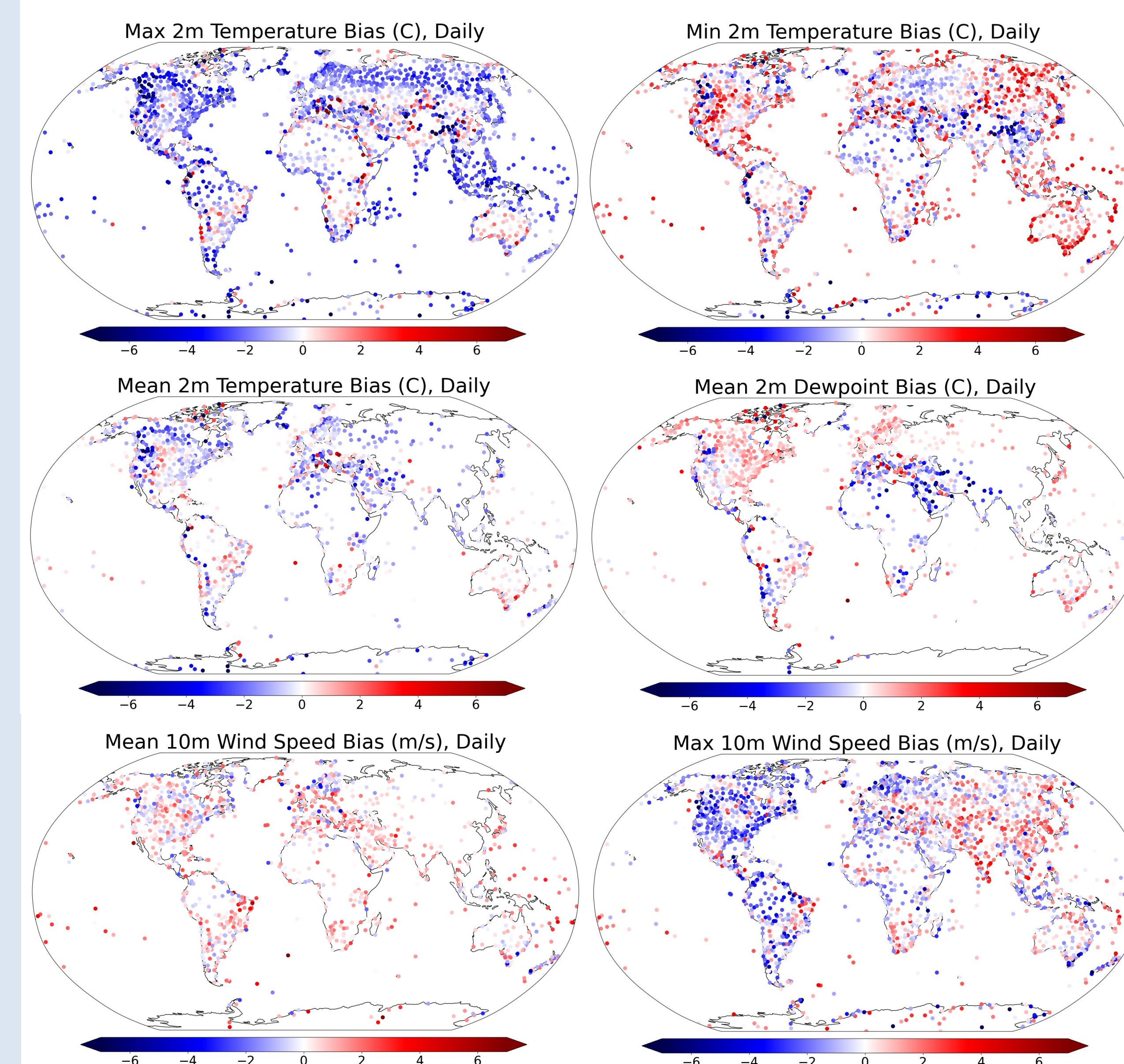
- IMERG tends to over-estimate precipitation amounts
- For current IMERG version, no noticeable improvement over MERRA-2

Source - Period	Accumulation - Precipitation Only Events					
	Bias	Std. Dev	RMS	CC	Slope	Inte rcept
IMERG - Weekly	2.09	28.92	29.00	0.71	0.70	9.32
MERRA2 - Weekly	-0.18	24.87	24.87	0.76	0.61	9.33
IMERG - Monthly	8.79	59.25	59.90	0.84	0.83	8
MERRA2 - Monthly	1.31	57.31	57.32	0.84	0.74	7

## Acknowledgement

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## Maps of Bias by Surface Site for Daily

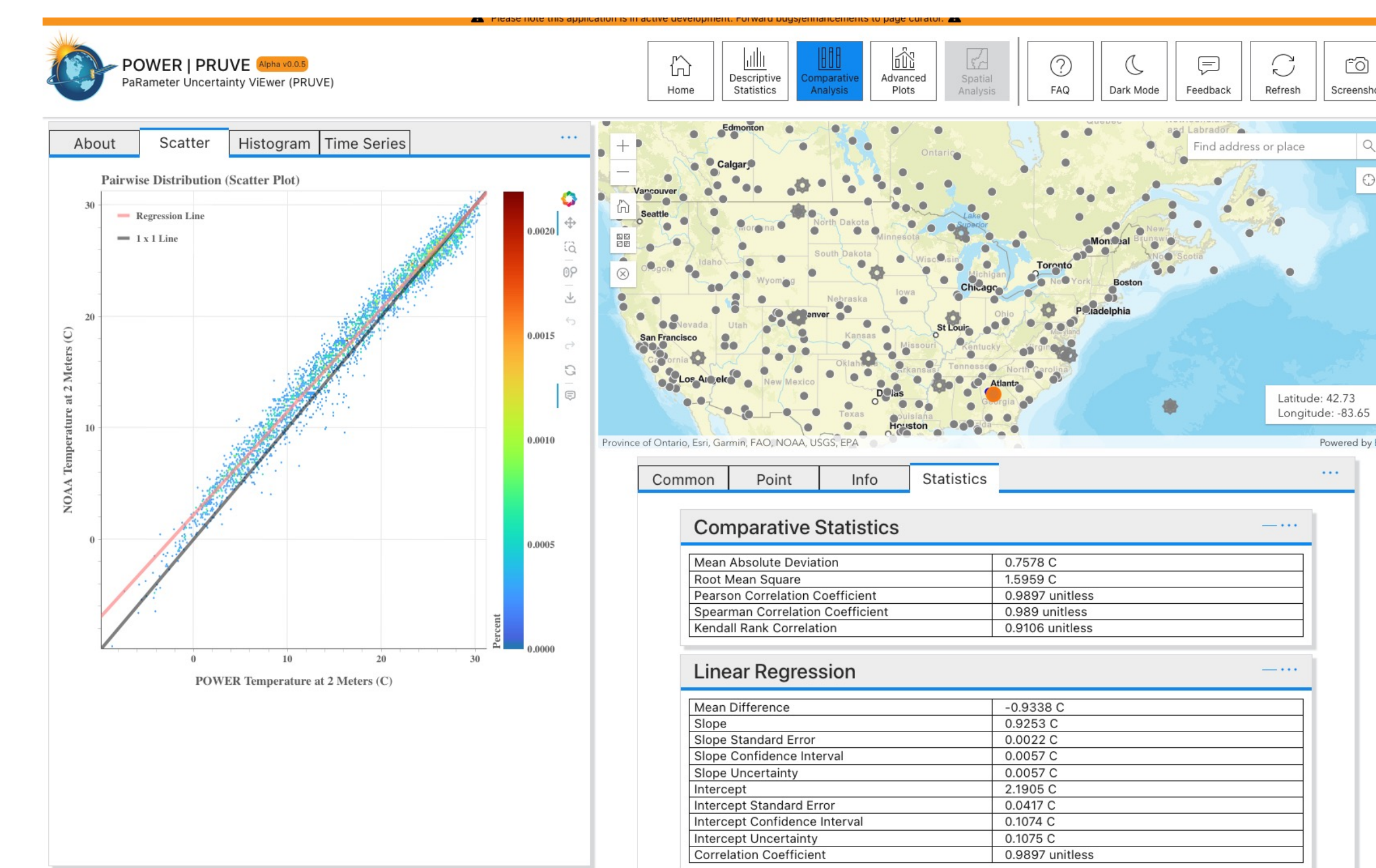


- Daily maximum 2m temperature is uniform in distribution of negative bias globally
- Daily minimum 2m temperature has more variation globally, extremes cancelling for single bias number
- Daily maximum 10m wind speed shows a tendency for underpredicting in Americas and Western Europe, over-predicting in Asia

## POWER's Upcoming Online Validation Tool

The NASA Prediction Of Worldwide Energy Resources (POWER) project's PaParameter Uncertainty VIewer (PRUVE) will allow the POWER data user to perform similar statistical analysis and visualizations of comparisons with surface site data.

This preview shows a glimpse of the capability of this new tool. The POWER team expects to release the tool in the first quarter of 2024.



## References

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