



The Use of MERRA-2 for Building Energy Analysis

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Energy, Climate and NASA

- In the US, residential and commercial building infrastructure combined consumes about 40% of total energy usage and emits about 39% of total CO₂ emission (DOE/EIA "Annual Energy Outlook 2013"). *Thus, increasing the energy efficiency of buildings is paramount to reducing energy costs and emissions.*
- Building codes, as used by local and state enforcement entities are typically tied to the dominant climate, *defined according to a building climate zone* which is based upon a 30-year average of local to regional surface observations.
- Guidelines for these codes, applied to all residential and commercial buildings, are developed by Department of Energy (DOE) and ASHRAE (formerly known as the American Society of Heating, Refrigeration and Air-Conditioning Engineers).
- Using NASA MERRA(-2), we are now working to provide long-term global surface meteorological parameters to provide key surface temperature, humidity, wind and precipitation parameters for building energy performance planning, targeting and verification.
 - Supplements sparse or low quality surface measurements
 - Applicable worldwide



Needed Building Related Parameters

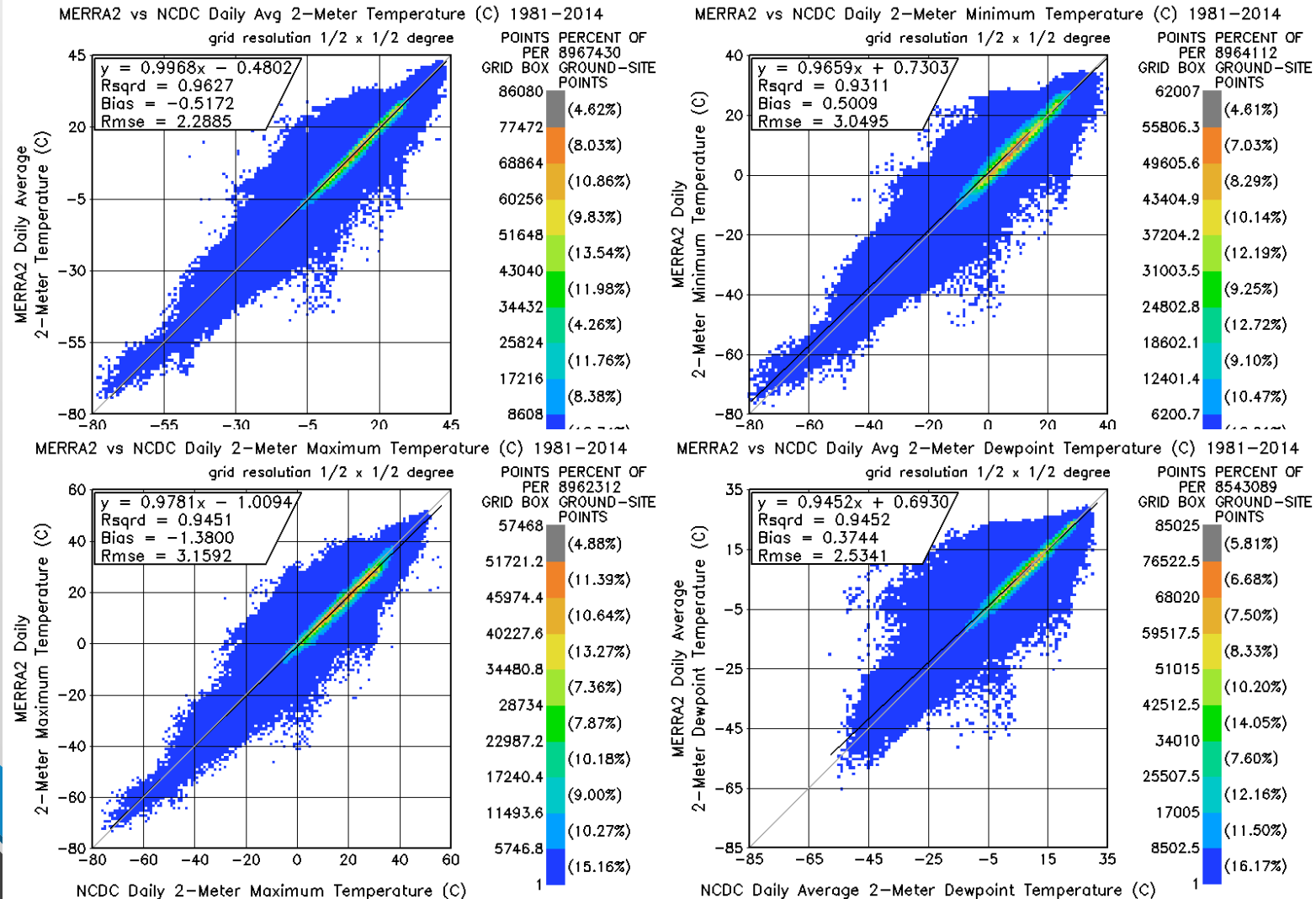
General Usage	Meteorological Parameters	Ref Time	Temporal Averages
Climate Type Zone	T2m, T2m-min, T2m-max, Precipitation	Local	Daily, Monthly, Annual
Climate Design Conditions	T2m, T2m-min, T2m-max, T2m-wtblb, T2m-dwpt, SH2m, WndDir-10m, Wspd-10m, SPres, Clear-sky SW/tau-dir-norm & SW/tau-dif (noon only)	Local	Hourly, daily, monthly
Near-Real Time Energy Monitoring	T2m, T2m-min, T2m-max, T2m-dwpt, T2m-frost, Tskin, Precipitation, SPres, SH2m, RH, Wspd-10m, SWsurf-total-down, SWtoa-down, LWsurf-down, Clear-sky SWsurf-total-down	Local	Daily

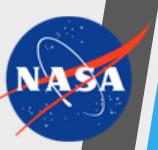
Radiation fluxes determine from CERES/GEWEX SRB projects



Parameter Validation Critical

($1/2^\circ \times 1/2^\circ$ MERRA-2 compared to NOAA GSOD Sites: 1981-2014, every 3rd year)





Climate Zone Definitions

Heating Degree Days:

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

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

Cooling Degree Days:

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

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

⁺ Positive definite:
negative values are not
included in sum

Table A-3 Climate Zone Definitions (taken from Proposed Addendum b to Standard 169, Climate Data for Building Design Standards).

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

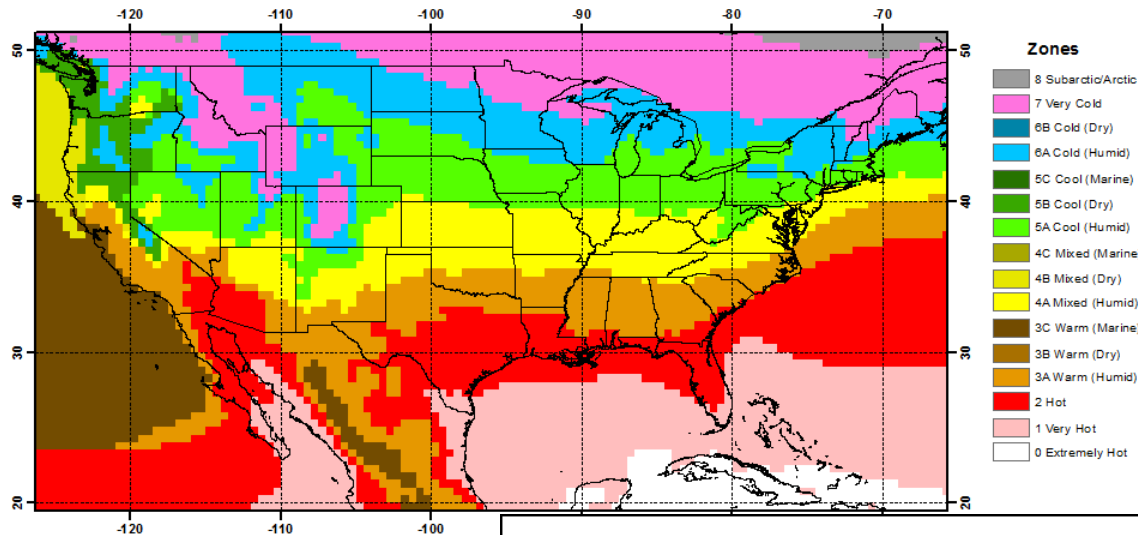
The criteria for dry and humid are similar but not identical to those enumerated in Table 2B above.

Dry/Humid are classified by using monthly mean temperatures with monthly/annual precipitation



1984 - 2013 Climate Zones

30 Years 1/2 x 1/2 Degree United States Grid



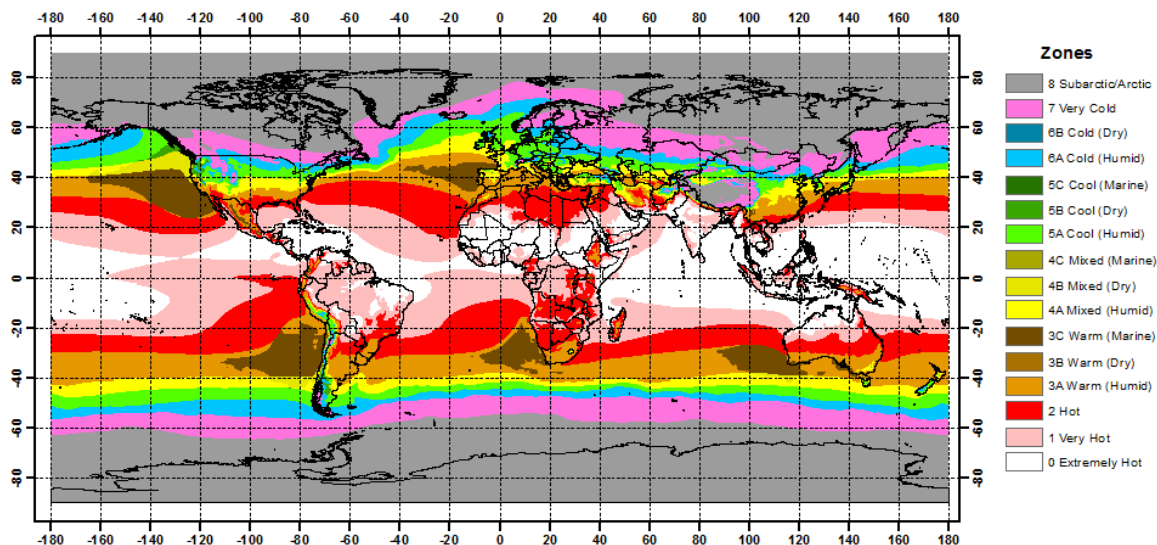
ASHRAE Building Climate Zones

Global is particularly valuable due to sparse sampling and inconsistency of surface long-term measurement records



1984 - 2013 Climate Zones

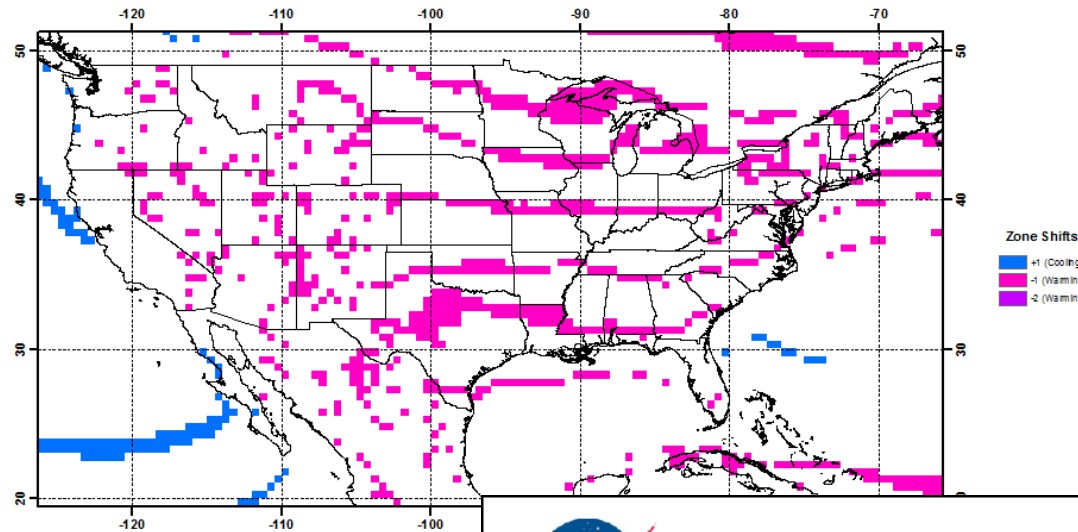
30 Years 1/2 x 1/2 Degree Global Grid





Climate Zone Comparison

15 Year Periods 1/2 x 1/2 Degree United States Grid
1984 - 1998 vs 1999 - 2013



ASHRAE Building Climate Zone Changes

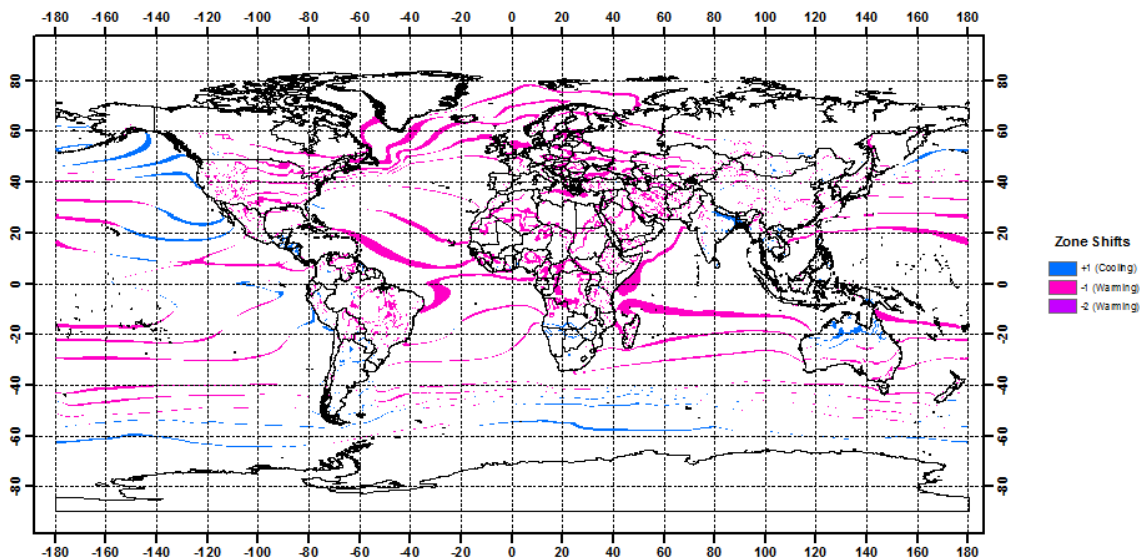
Differences of climate
zones from 1999-2013
to 1984-1998

Changes > 0 cooling
Changes < 0 warming



Climate Zone Comparison

15 Year Periods 1/2 x 1/2 Degree Global Grid
1984 - 1998 vs 1999 - 2013





Near-Real Time Energy Analysis at For NASA LaRC Buildings

NASA data
and/or surface
measurements

CERES
FLASHFLux
(using GMAO
FP-IT)

NRT Time Series
POWER web
portal

RETScreen
Energy
Analysis

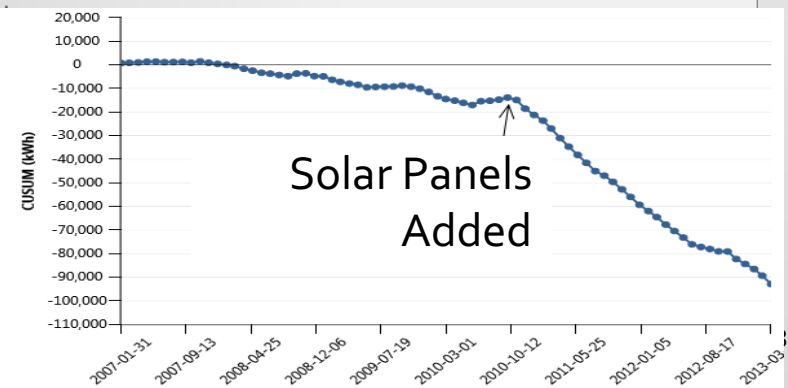
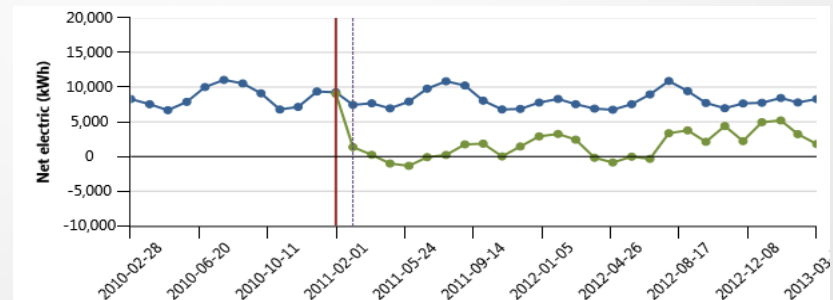
4 building energy
assessments
working with
center energy
management
officials and
RETScreen

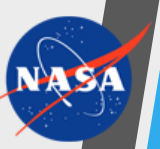


Steady state RETScreen regression
models provide for energy
performance analysis (NASA TMs
available).

*(Supported by NASA's Science
Division)*

Net Savings 160 MWh (2/10–3/13)





Summary and Conclusions

- Building Energy Managers and Architects need consistent long-term surface meteorological and solar parameters to design specifications for new/modified buildings and monitor energy performance
- NASA's MERRA-2 data products are being evaluated for usage by ASHRAE to improve global specification of climate zones and more detailed design conditions
- Near-real time data products are useful for monitoring building energy performance using decision support tools like RETScreen
- NASA LaRC is tailoring the relevant parameters from MERRA-2, CERES/GEWEX SRB for usage in energy efficiency; the POWER web site provides parameters in a variety of data formats using GIS tools.



power.larc.nasa.gov

POWER Data Access Viewer

Prediction Of Worldwide Energy Resource

Esri World Geocoder

Questions?

<https://power.larc.nasa.gov>

POWER Single Point Data Access

- 1. Choose a User Community**
SSE-Renewable Energy
- 2. Choose a Temporal Average**
☒ Daily ☐ Interannual ☐ Climatology
- 3. Enter Lat/Lon or Add a Point to Map**
Latitude (Decimal Degrees)
Longitude (Decimal Degrees)
Clear
- 4. Select Time Extent**
Start Date: 01/01/2015 (MM/DD/YYYY)
End Date: 03/05/2015 (MM/DD/YYYY)
- 5. Select Output File Formats**
☐ Select All
☒ ASCII ☐ CSV ☐ GeoJSON ☐ ICASA ☐ NetCDF
- 6. Select Parameters**
☐ Select All
Insolation on a Horizontal Surface

Welcome to the POWER Data Access Viewer!

The POWER Data Access Viewer contains meteorology and solar related parameters formulated for assessing and designing renewable energy systems.

If you have any comments or questions about POWER, please do not hesitate to contact us at power-projects@lists.nasa.gov

View our [User Guide](#) for more information on the application and data access options.

☐ Do not show this splash screen again.

[Access Data](#)

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