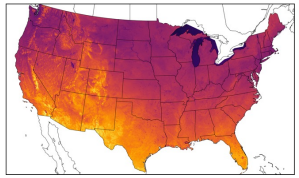
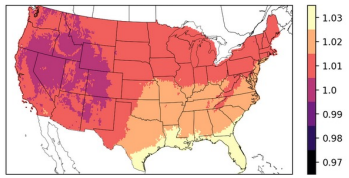
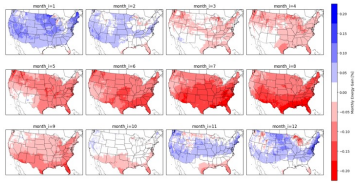
PV Atlas: charting a course to geographic insights for PV performance modeling







Kevin Anderson

Sandia National Laboratories

2024 PVPMC Workshop – Salt Lake City

May 7, 2024

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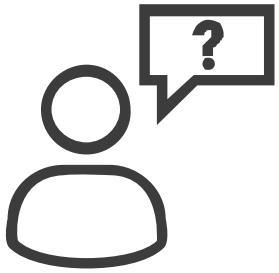
Problem: PV modeling and analysis is complicated



Questions:

Module manufacturer:
- What's the value of a smaller temperature coefficient?
- How much extra energy do you get with a better anti-reflective coating?

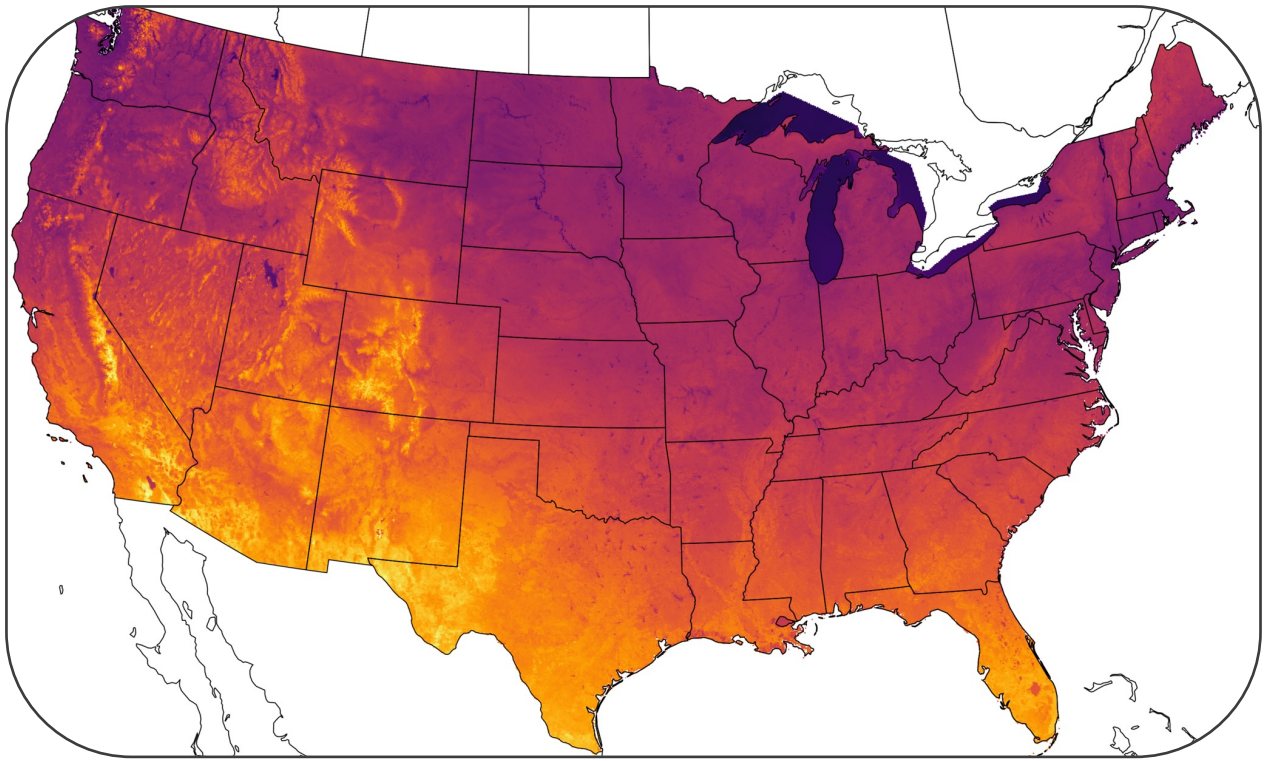
Development engineer:
- Do I need to be modeling spectral effects?
- What about thermal transience?

O&M/AM analyst:
- How many years of data do I need for reliable PLR estimates?
- How does missing data affect uncertainty for PR and other KPIs?

Answer: Well, it depends…

Climate and location make a difference

Geographic insights in PV modeling and analysis



- Interactive maps
- Best practices
- Reduced-order models
- Geographic data files

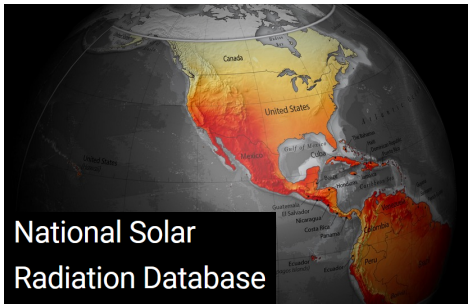


PV Atlas: Methods

Project requirements

Weather data

- High spatial resolution
- Decades of sub-hourly data



PV model

- Highly customizable
- Highly automatable

POWERED BY pvlib

Computing

- Highly scalable
- Large storage

Methods: weather data

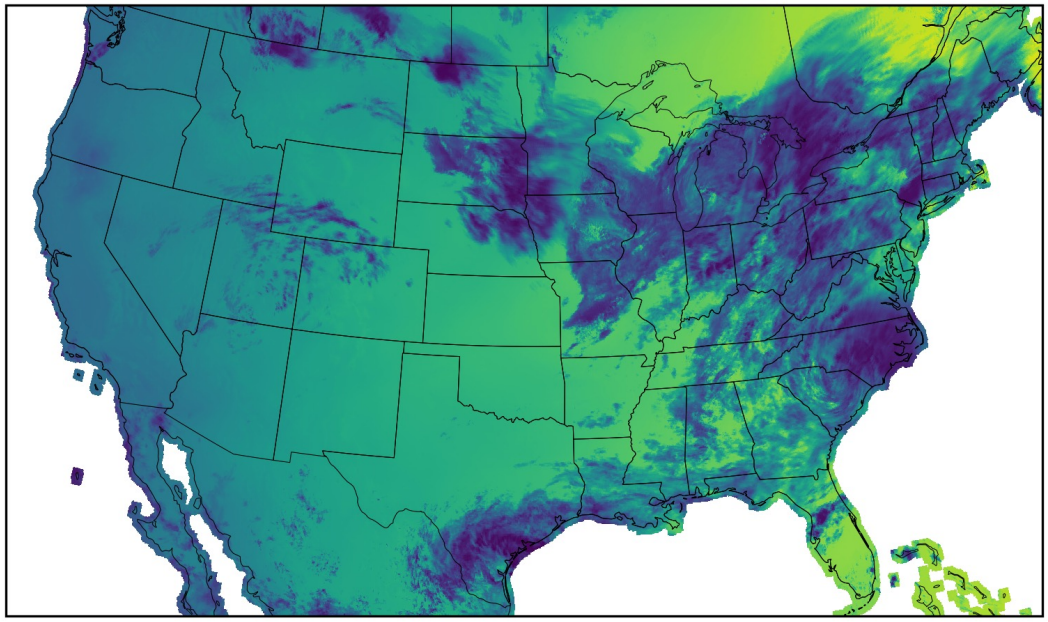
25 years of NSRDB data

- 4 km, 30 minute resolution
- 546,938 pixels in the United States
- 2,018,267 pixels total

Spectral irradiance from FARMS-NIT

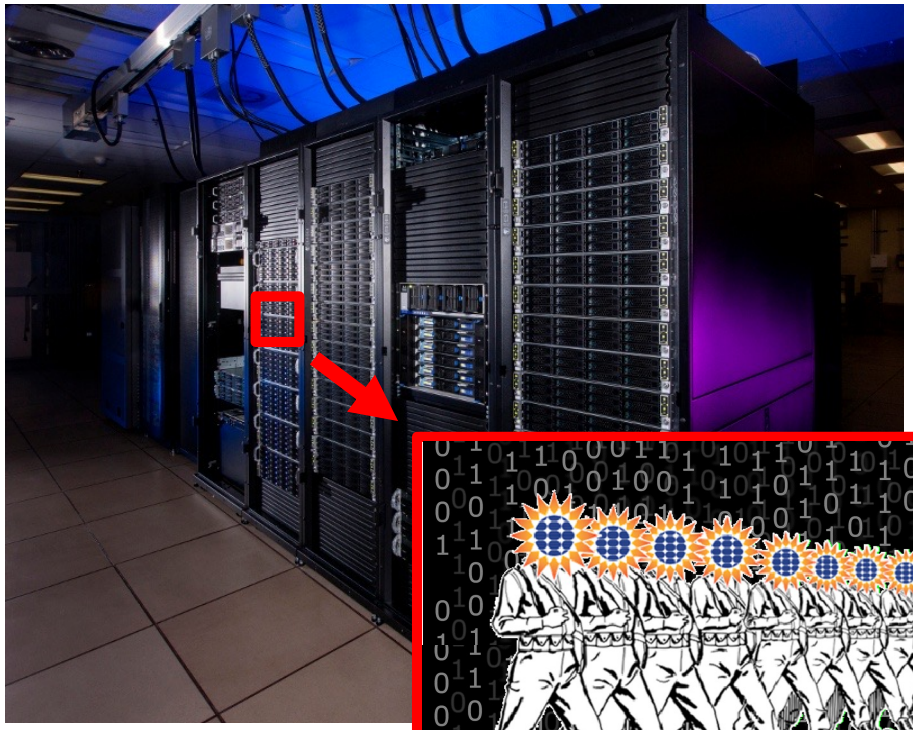
Planned:

- 5-minute NSRDB
- ERA5



Hurricane Elsa over North Carolina. PSM v3.2.2 GHI data for July 8, 2021.

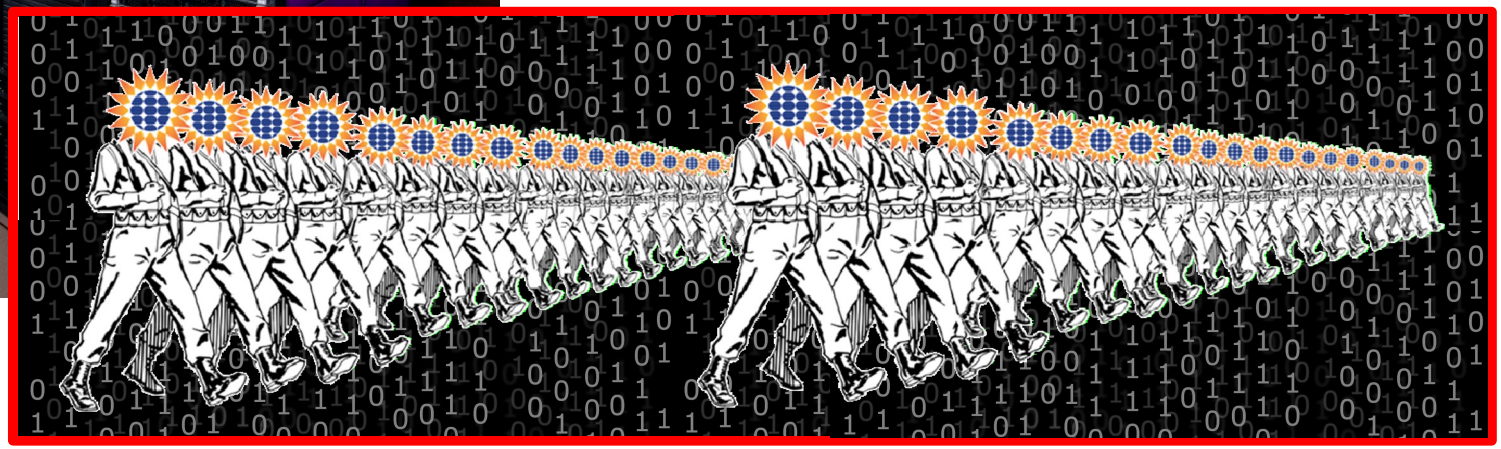
Methods: HPC



POWERED BY pvlib

Main NSRDB dataset: 37 TB
How many simulations? Millions (billions?)

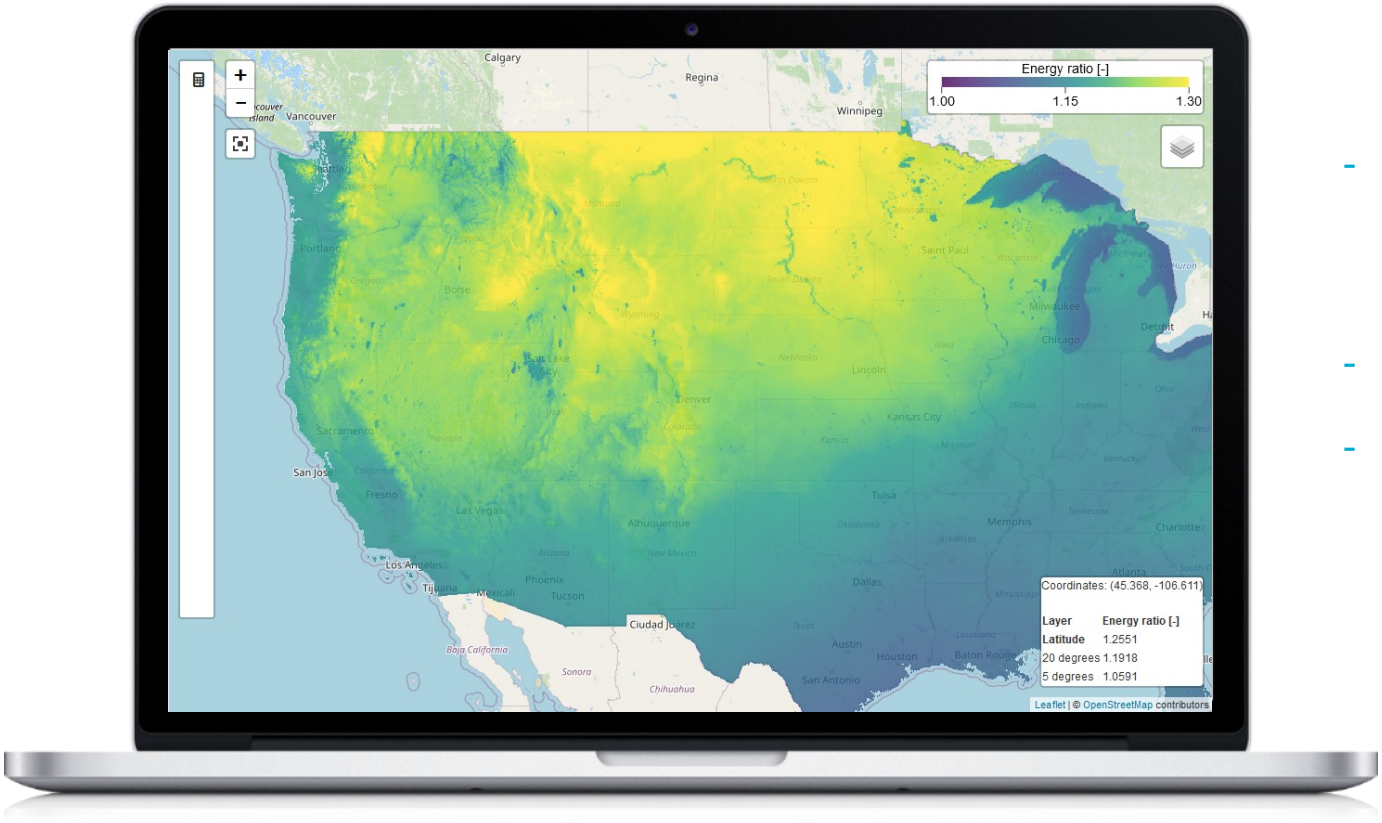
A typical simulation job: 1000+ CPU cores
Biggest pvlib application ever? Maybe





PV Atlas: Outputs

PV Atlas: website



- Topic-focused chapters
  - Interactive maps
  - Narrative explanation
- Dozens of chapters
- Hundreds of maps

Other project outputs

Rules of thumb

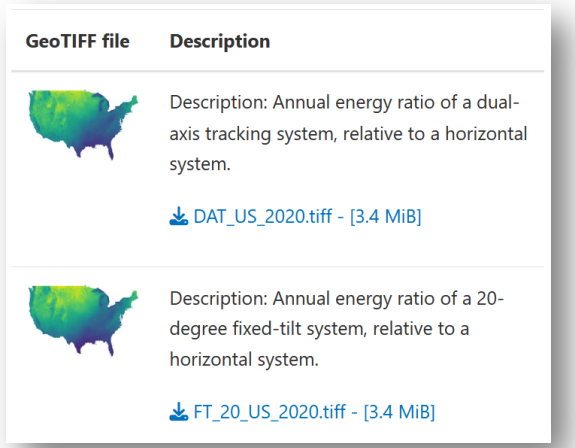
- Climate-specific best practices

Reduced-order models

- Simple empirical models for rough estimates
- Example: estimate annual SCF based on elevation and PV technology

GeoTIFF files

- Geo-referenced raster data
- Metadata: units, description, data version…

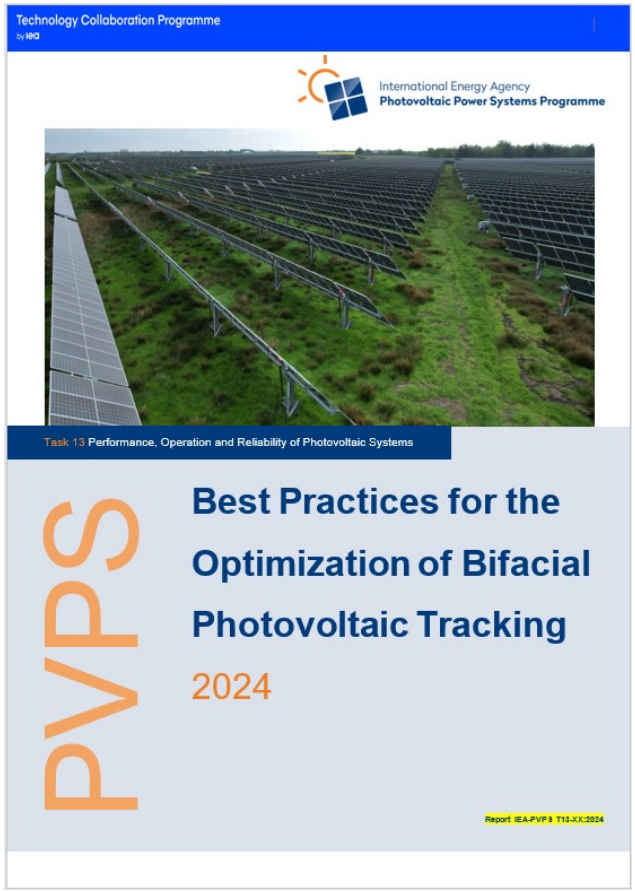


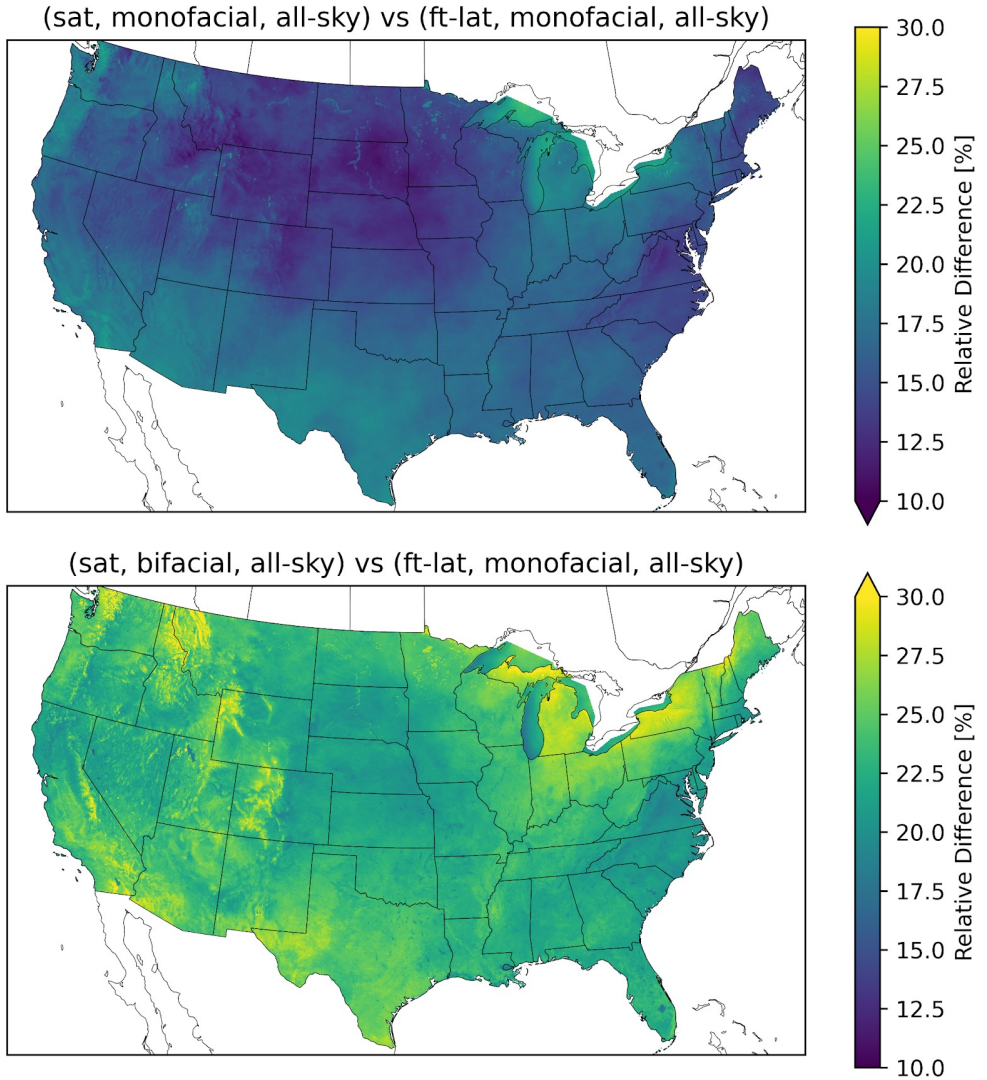
GeoTIFF file	Description
	Description: Annual energy ratio of a dual-axis tracking system, relative to a horizontal system. DAT_US_2020.tiff - [3.4 MiB]
	Description: Annual energy ratio of a 20-degree fixed-tilt system, relative to a horizontal system. FT_20_US_2020.tiff - [3.4 MiB]



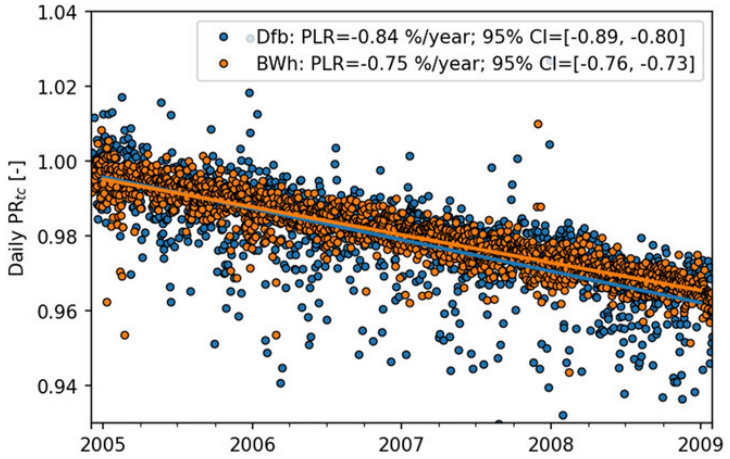
PV Atlas: Case studies

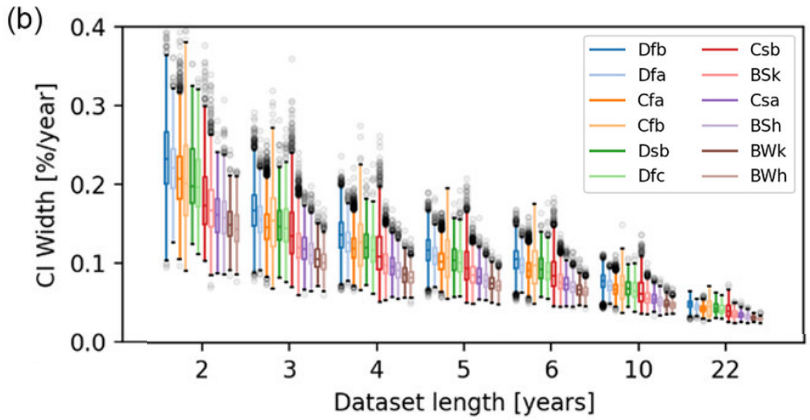
IEA PVPS Task 13 maps

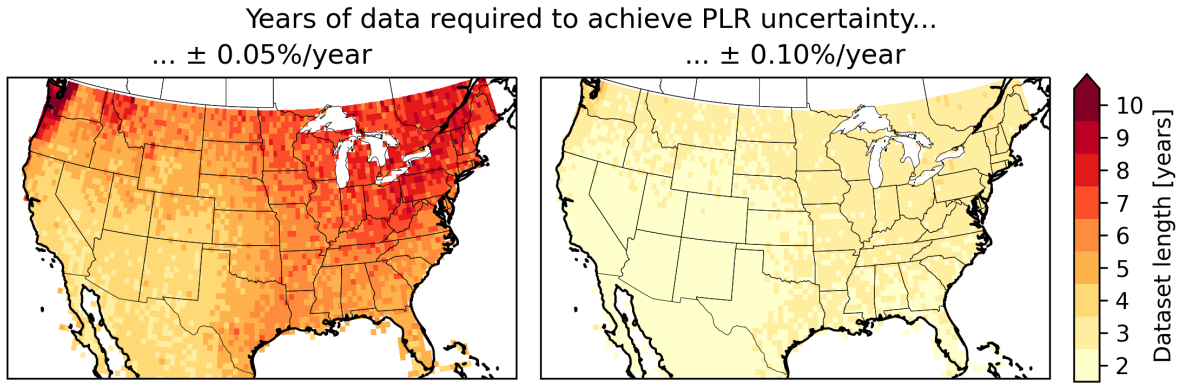




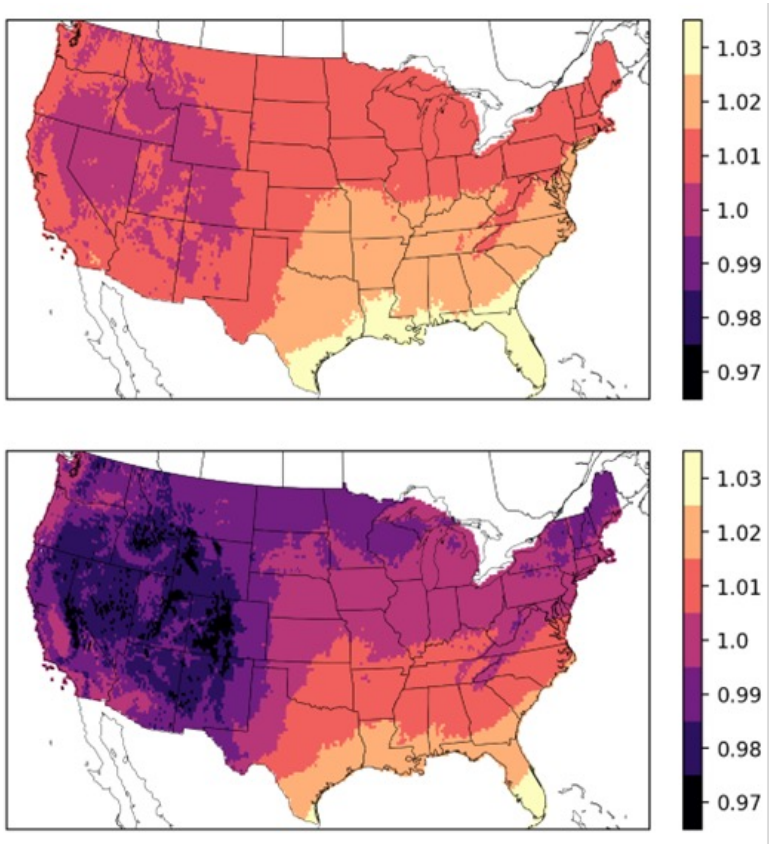
PLR estimation uncertainty

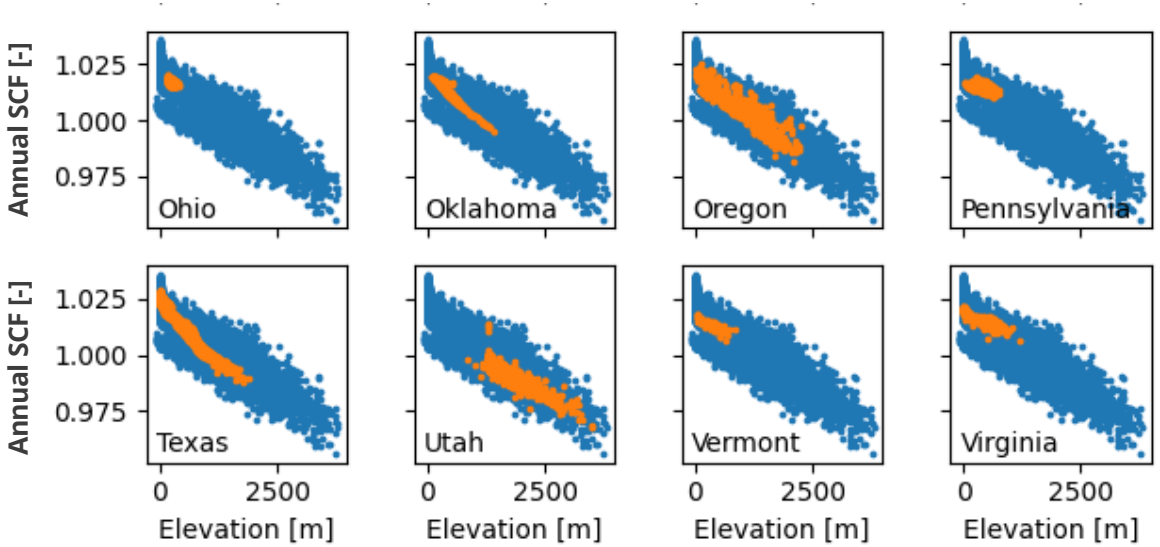




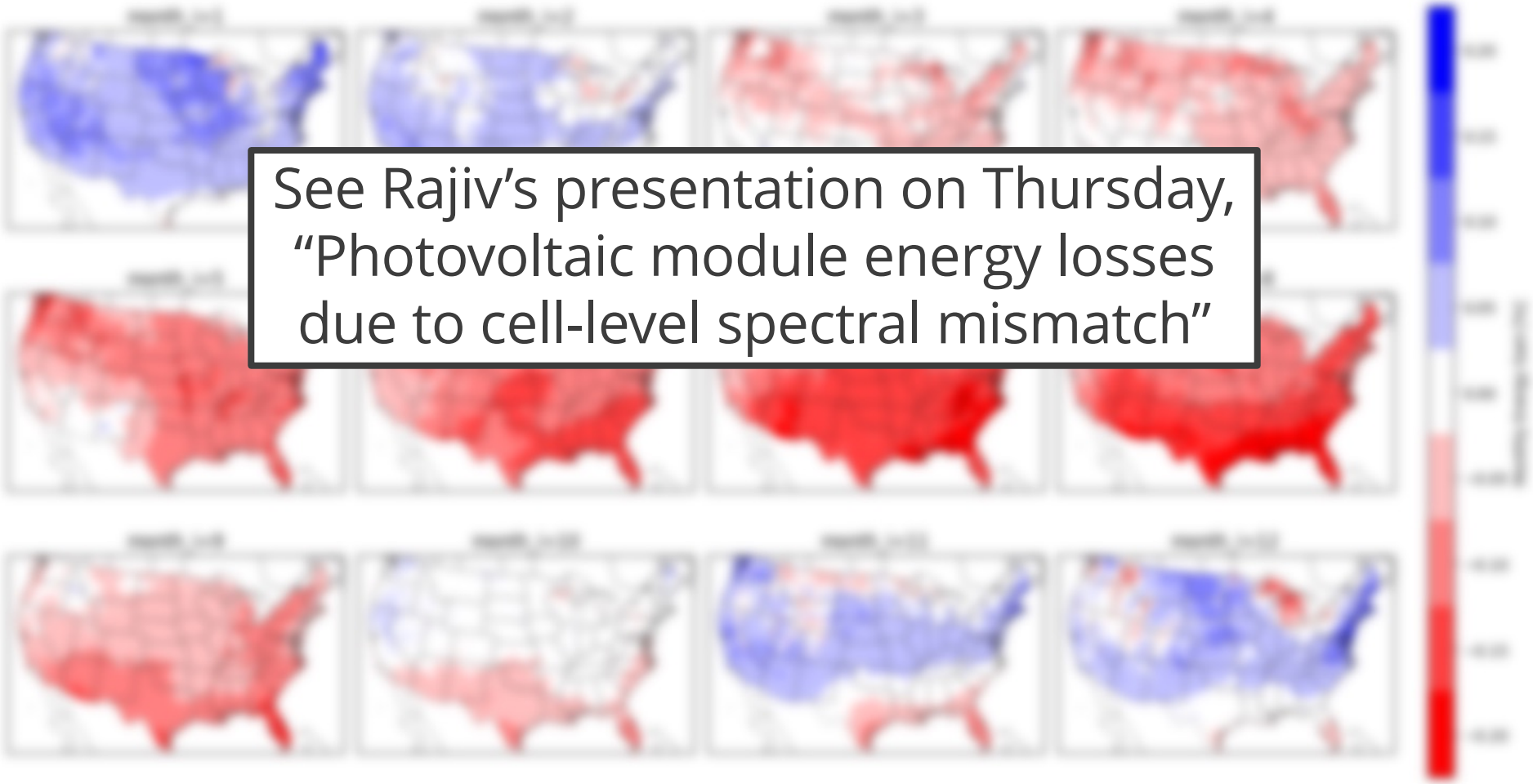


Spectral correction factors





Cell-level spectral mismatch



See Rajiv's presentation on Thursday, "Photovoltaic module energy losses due to cell-level spectral mismatch"

PV Atlas: the future

Modeling

- Effect of data time scale (5min, 30min, hourly)
- Derate factors (e.g. soiling, snow)
- Forward-looking NSRDB data?

Analytics

- Capacity testing
  - Number of days required to satisfy ASTM E2848 filtering
  - Evaluate proposed revisions to capacity testing methodology
- KPIs
  - Technology-specific uncertainty/variability
  - Relationship between amount of missing data and metric uncertainty

PVPerformance MODELING COLLABORATIVE

Please join the PVPMC at https://pvpmc.sandia.gov/ Contribute, and help increase confidence in PV system performance

Thank you!

Kevin Anderson

ksande@sandia.gov

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SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

Solar Energy Technologies Office Award Number 38267