SAND2023-11760C

pvlib 2023 update: pvlib-python, pvanalytics, twoaxistracking

pvlib-python

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pvanalytics

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twoaxistracking

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2023 European PVPMC Workshop

Mendrisio, Switzerland, November 9, 2023

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1. What is pvlib?
2. What is pvlib python
3. Documentation and Tutorials
4. Enhancements since v0.6 (2018)
5. Community Growth
6. Introductions to pvanalytics and twoaxistracking

What is pvlib?

A python ecosystem of compatible packages for PV systems modeling and analysis that are **community-driven**, **free**, **open-source**, and **well-documented**

pvlib-python

Library of functions for weather-to-power modeling

Customizable end-to-end PV system modeling (ModelChain)

Batteries-included data import library

pvanalytics

Library of functions for analysis of data from PV systems

Filtering and quality checks

Feature labeling: e.g., inverter clipping

twoaxistracking

Simulate two-axis tracking solar collectors

Emphasis on self-shading

Find us at: https://github.com/pvlib

What is pvlib python?

A python library for PV performance modeling

Modeling Toolbox

Stand-alone models for:

Atmosphere	Snow
Solar position	Soiling
Transposition	Shading
Bifacial	I-V curves
Temperature	Inverters
Clear-sky	IAM

…and more!

Weather-to-power workflow

Customizable end-to-end PV system modeling (ModelChain)

Scriptable and automatable by design

Data I/O

Batteries-included data import:

TMY	SURFRAD
EPW	SOLRAD
NSRDB	MIDC
PVGIS	BSRN
CAMS	UO SRML
ECMWF MACC	NOAA USCRN

pvlib

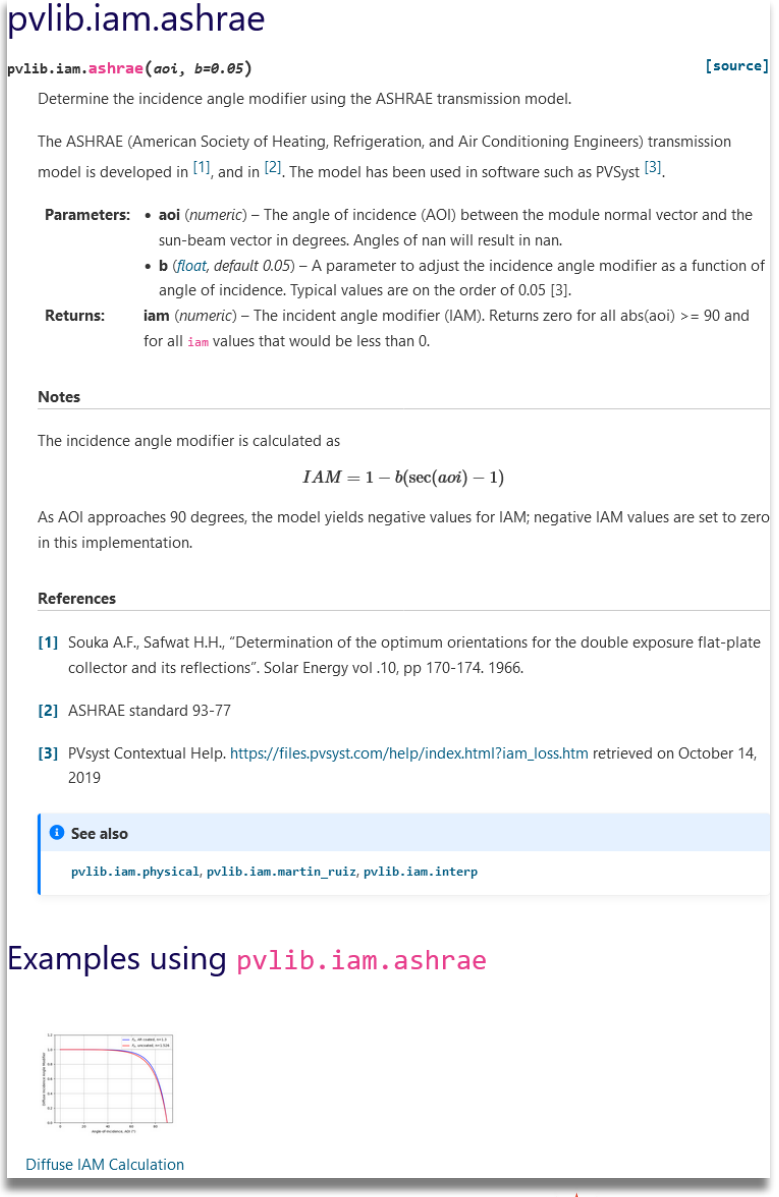
pvlib python Documentation: Model Descriptions

Each model function has a page with:

- Brief model description
- Inputs: description, data types, units
- Outputs: description, date types, units
- Published reference(s) for the model
- Links to other relevant functions
- Links to relevant gallery examples
- Other notes as needed

Several hundred model-level pages, all built automatically from in-code documentation

https://pvlib-python.readthedocs.io



pvlib.iam.ashrae

pvlib.iam.ashrae(aoi, b=0.05) [source]

Determine the incidence angle modifier using the ASHRAE transmission model.

The ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers) transmission model is developed in [1], and in [2]. The model has been used in software such as PVSyst [3].

Parameters:
- aoi (numeric) – The angle of incidence (AOI) between the module normal vector and the sun-beam vector in degrees. Angles of nan will result in nan.
- b (float, default 0.05) – A parameter to adjust the incidence angle modifier as a function of angle of incidence. Typical values are on the order of 0.05 [3].

Returns: iam (numeric) – The incident angle modifier (IAM). Returns zero for all abs(aoi) >= 90 and for all iam values that would be less than 0.

Notes

The incidence angle modifier is calculated as

$$IAM = 1 - b(\sec(aoi) - 1)$$

As AOI approaches 90 degrees, the model yields negative values for IAM; negative IAM values are set to zero in this implementation.

References

[1] Souka A.F., Safwat H.H., "Determination of the optimum orientations for the double exposure flat-plate collector and its reflections". Solar Energy vol .10, pp 170-174. 1966.

[2] ASHRAE standard 93-77

[3] PVsyst Contextual Help. https://files.pvsyst.com/help/index.html?iam_loss.htm retrieved on October 14, 2019

See also

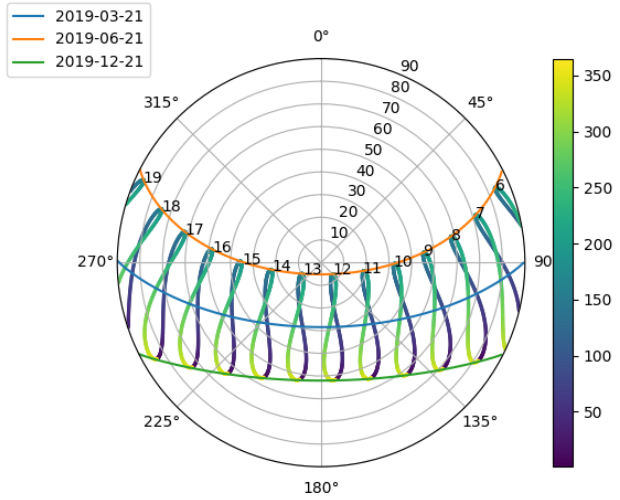
pvlib.iam.physical, pvlib.iam.martin_ruiz, pvlib.iam.interp

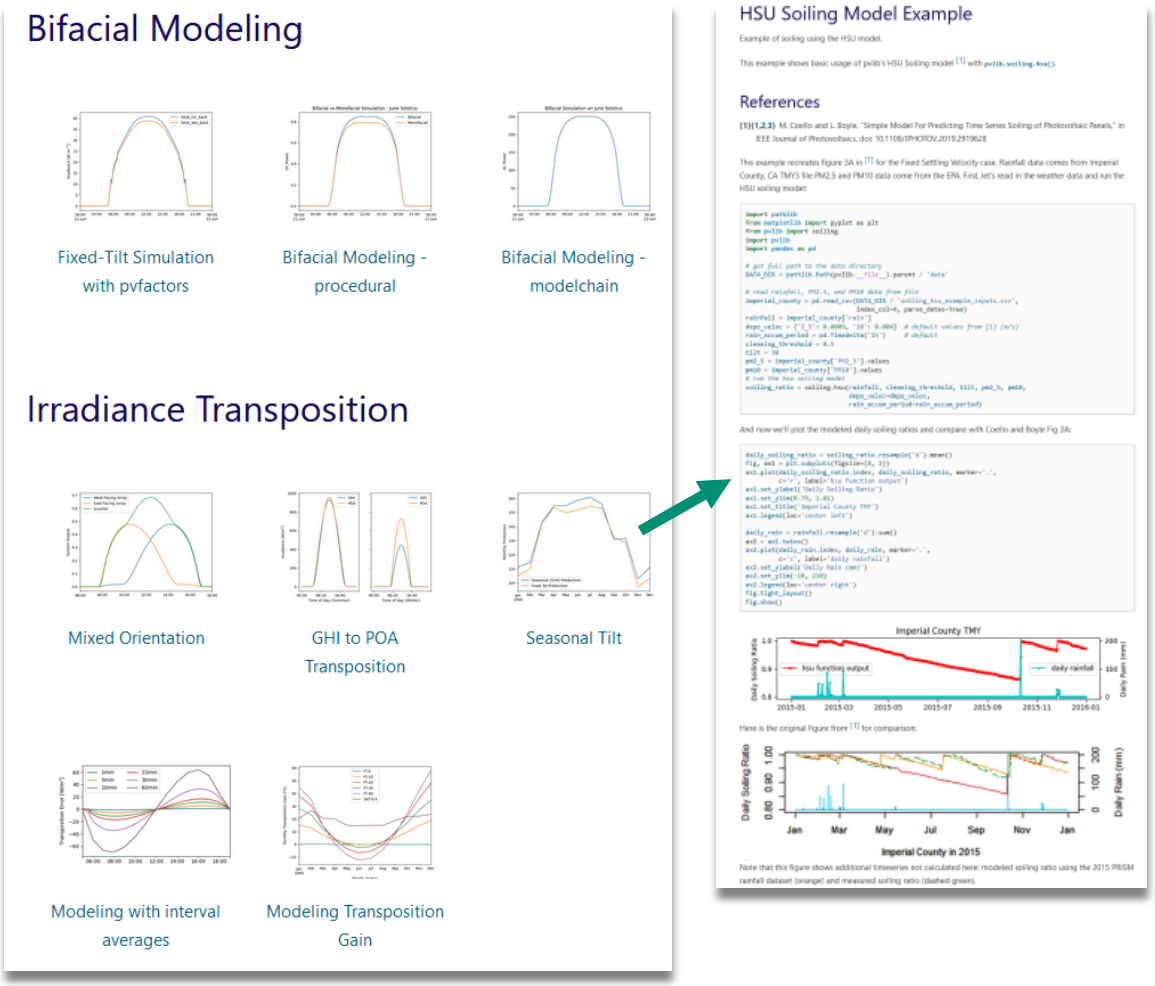
Examples using pvlib.iam.ashrae

Diffuse IAM Calculation

pvlib python Documentation: Example Gallery

pvlib “cookbook” -- small self-contained scripts for various modeling tasks, intended as a starting point for your own code.

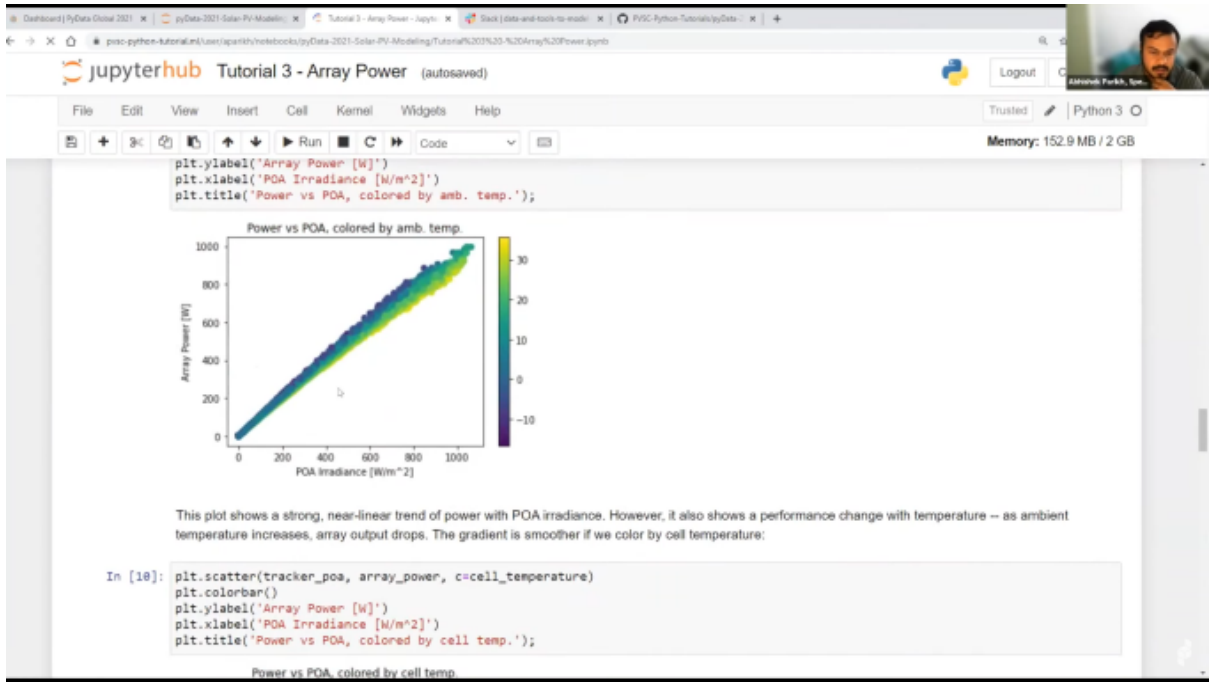




Want to make cool plots like this one? Check out the example gallery!

https://pvlib-python.readthedocs.io/en/stable/gallery/index.html

pvlib python: Tutorials



In-person and recorded tutorials for:

- Modeling concepts
- Implementation in pvlib

The next one is here, today!

Past tutorials

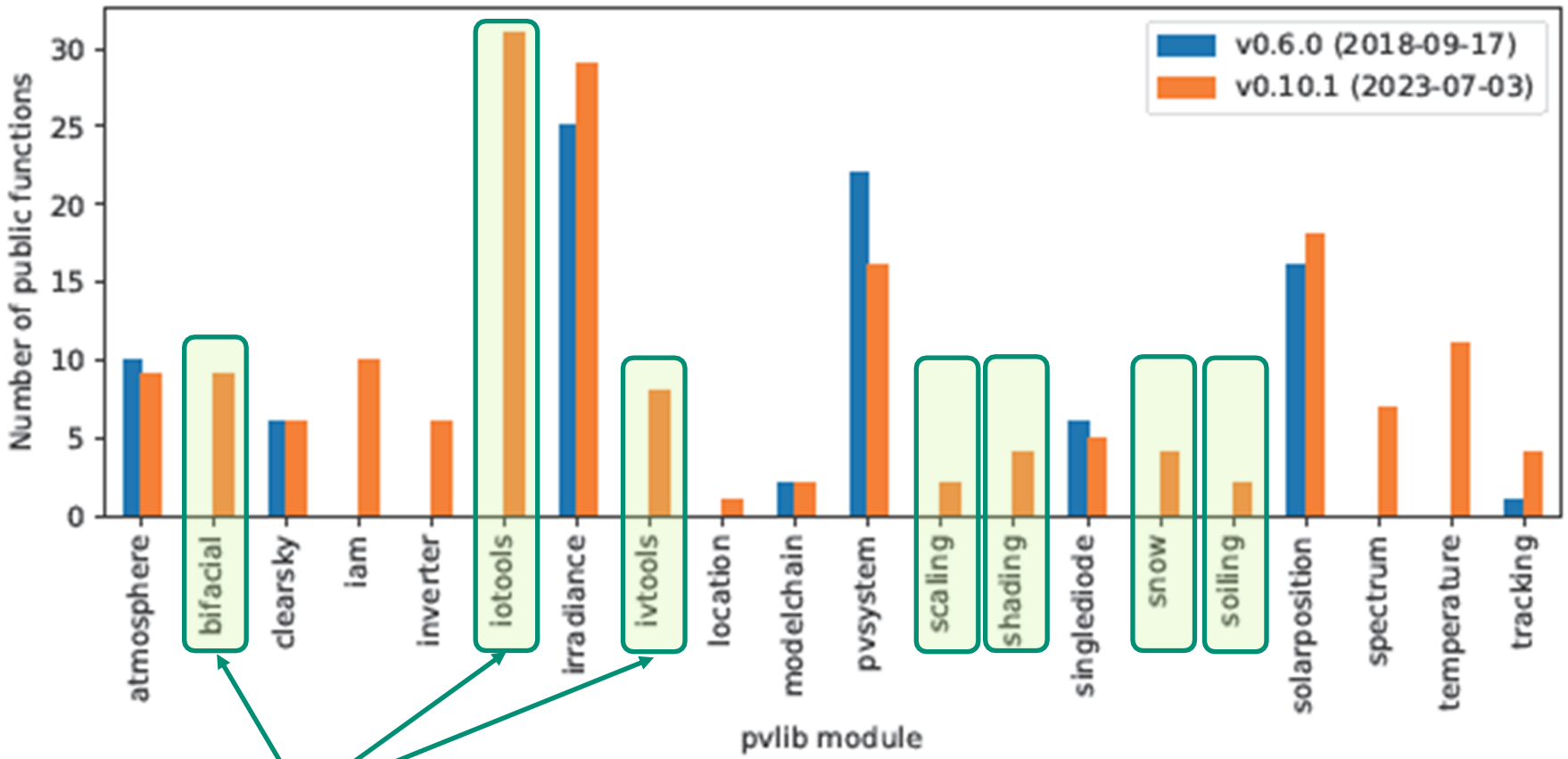
50th PVSC: https://github.com/PVSC-Python-Tutorials/PVSC50

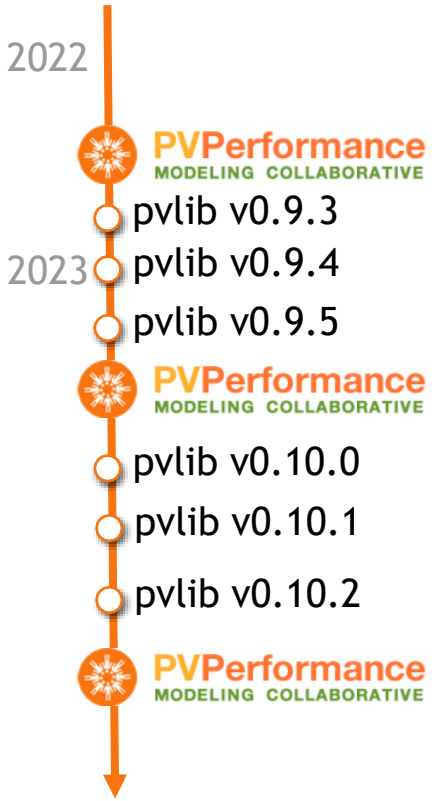
PVPMC 2022: https://github.com/PVSC-Python-Tutorials/PVPMC_2022

PVSC 2021: https://github.com/PVSC-Python-Tutorials/PVSC48-Python-Tutorial

PyData Global 2021
Youtube recording: https://www.youtube.com/watch?v=sweUakFg3I8
Source material: https://github.com/PVSC-Python-Tutorials/pyData-2021-Solar-PV-Modeling

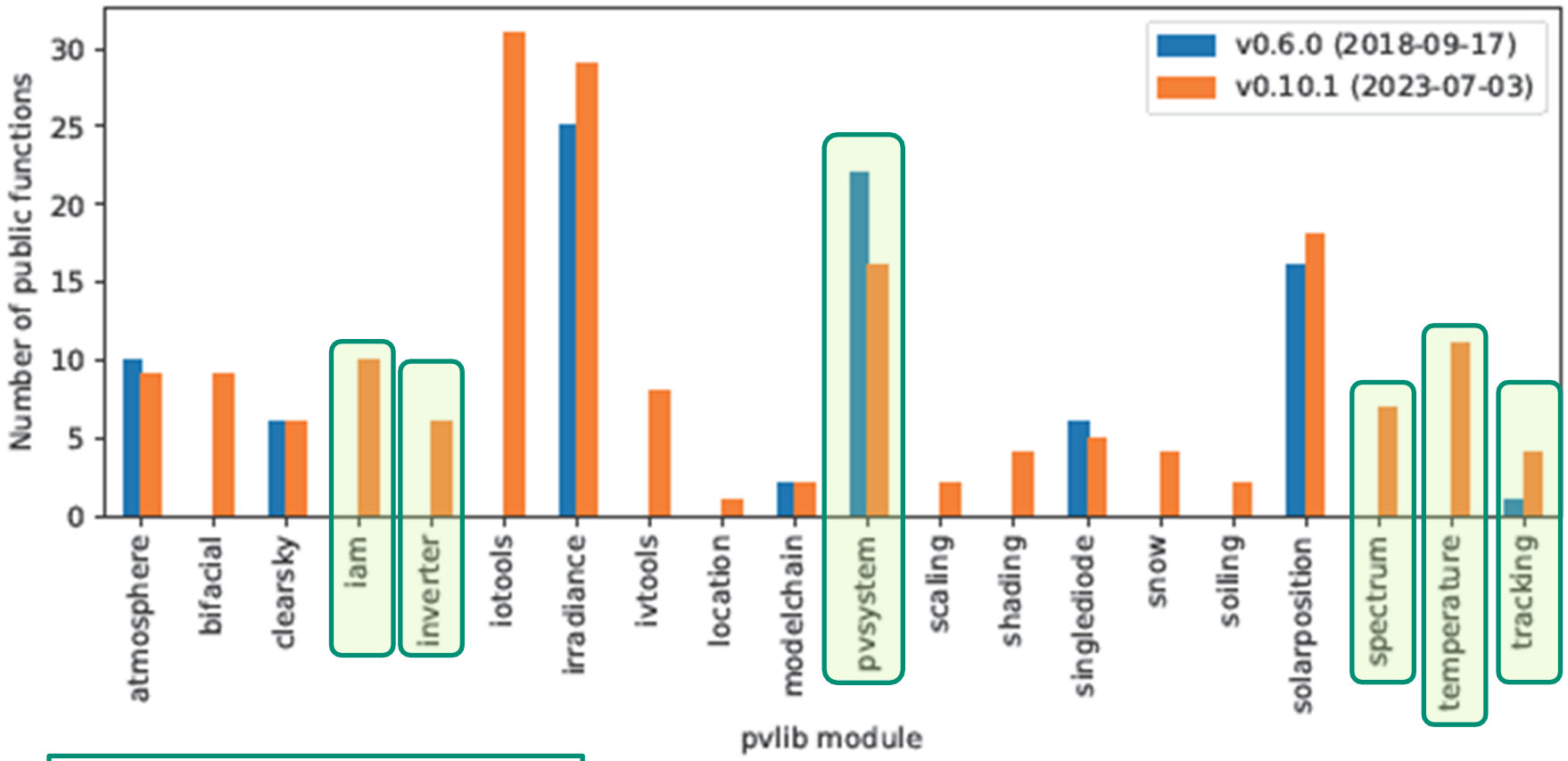
pvlib python since v0.6 (2018)

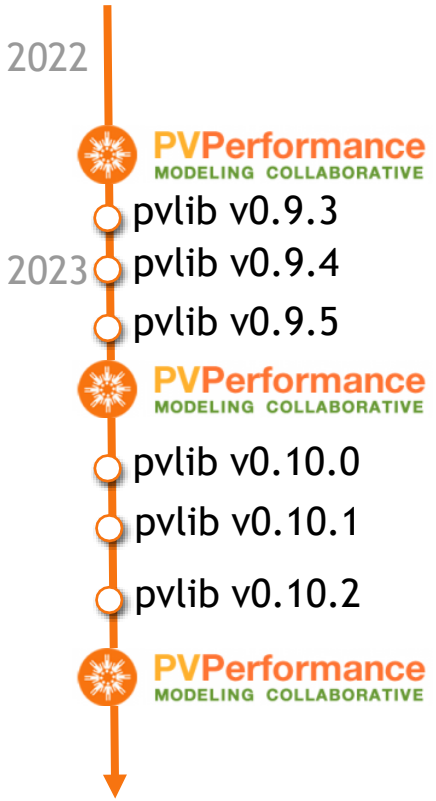




Full details: https://pvlib-python.readthedocs.io/en/stable/whatsnew.html

pvlib python since v0.6 (2018)





Better organization

Full details: https://pvlib-python.readthedocs.io/en/stable/whatsnew.html

pvlib python: Community Growth

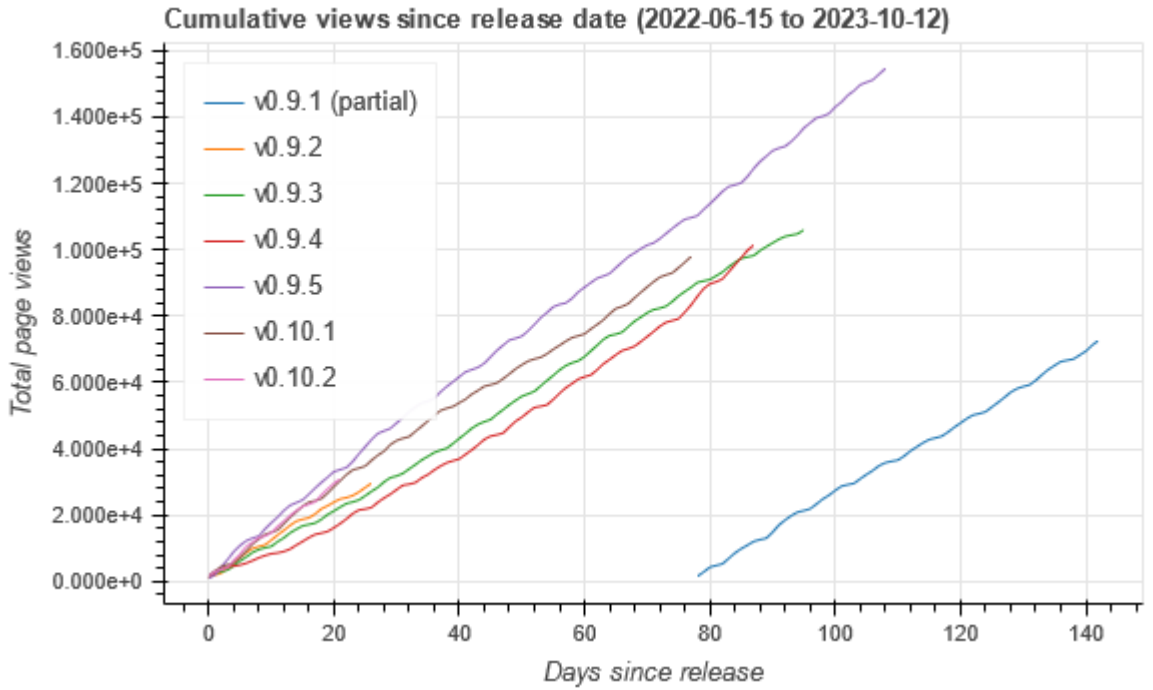
Google Group (user discussion, announcements)
- ~~600+~~ 700+ members
- https://groups.google.com/g/pvlib-python

GitHub (code development)
- Code contributions from ~~80+~~ ~~90+~~ 100+ people
- https://github.com/pvlib/pvlib-python

Citations
- 300+ since 2022
- Influence outside of PV modeling, e.g.,

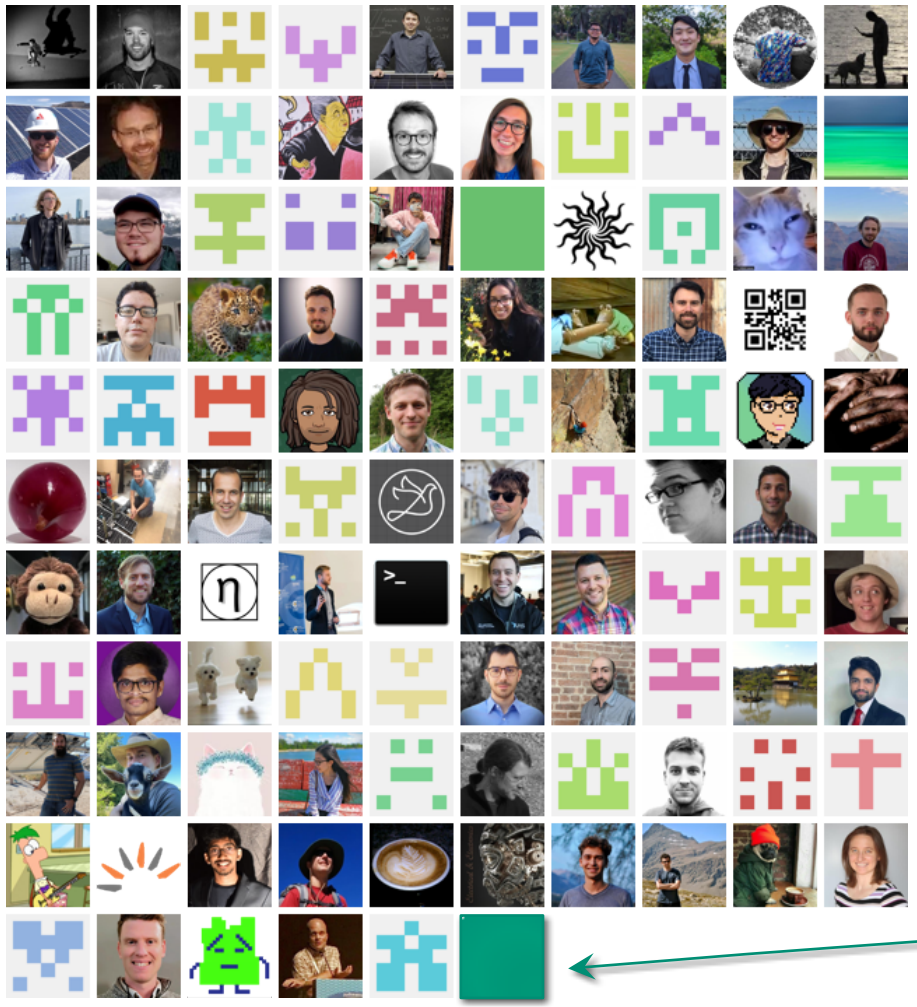
J. Rowland et al., *Scale-dependent influence of permafrost on riverbank erosion rates*. ESS Open Archive. February 09, 2023.

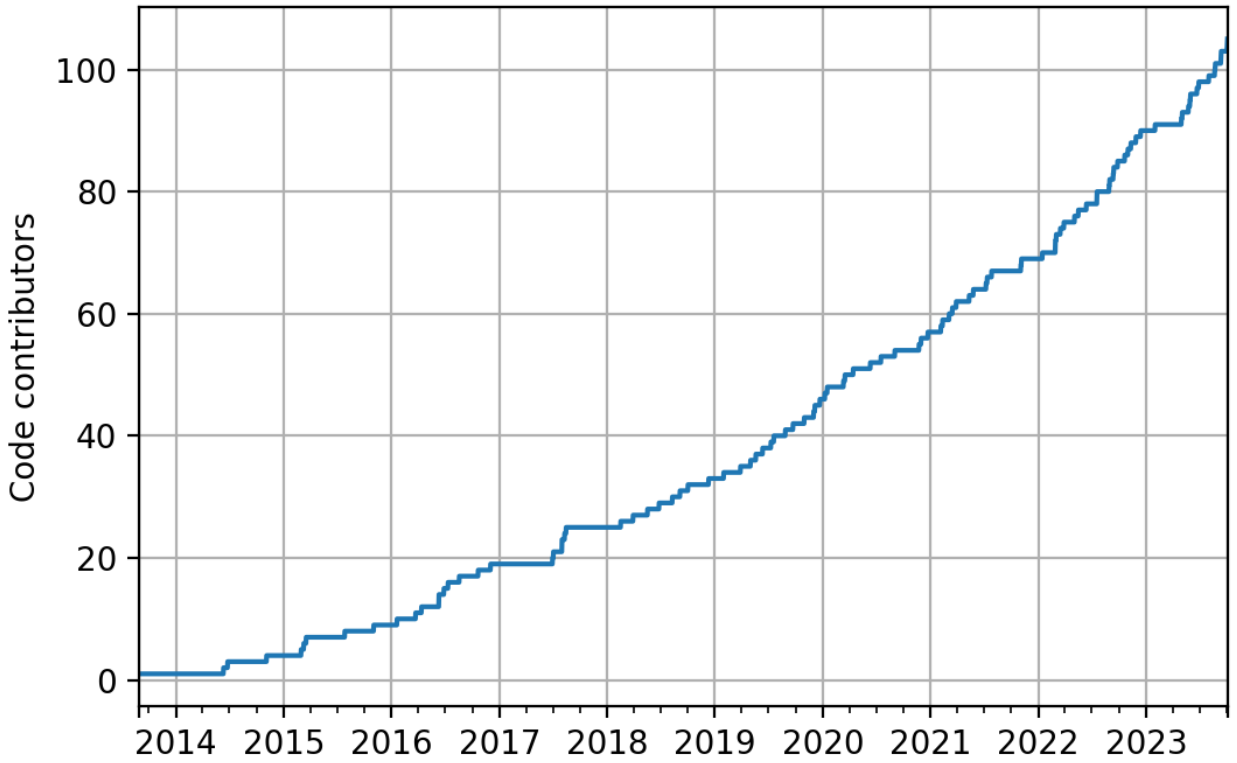
40k page views / month



pvlib python documentation page views

pvlib python: GitHub Contributors





*Not all contributions are code!

This software is made possible by contributions from people like you. You can help!

https://pvlib-python.readthedocs.io/en/stable/contributing.html

pvlib

What is pvanalytics?

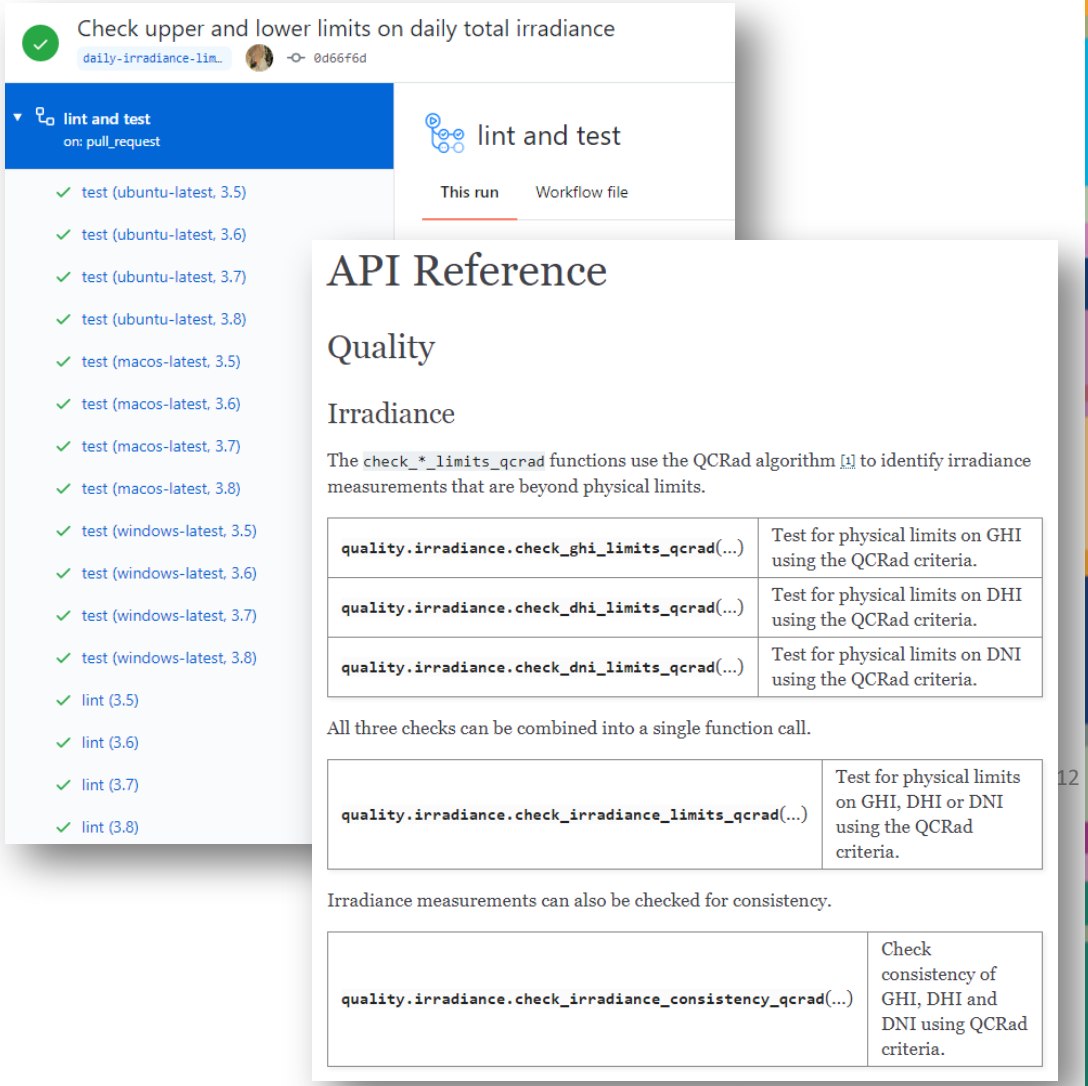
- Workflow-independent library of base functions
- Fully compatible with pvlib-python
- Launched Feb 2020, v0.1.3 Dec 2022
- 6 contributors, ~~23~~ 24 forks, ~~69~~ 76 stars

Quality control
- Plausibility of irradiance and weather measurements
- Identification of missing, interpolated, or stale data
- Outlier detection
- Identification of timestamp problems such as daylight savings shifts

Feature identification
- Inverter clipping
- Clear-sky periods
- Day/night detection from power or irradiance

Identification of system properties
- Tilt and azimuth from power data
- Differentiation between fixed and tracking PV systems

Metrics
- NREL weather corrected performance ratio

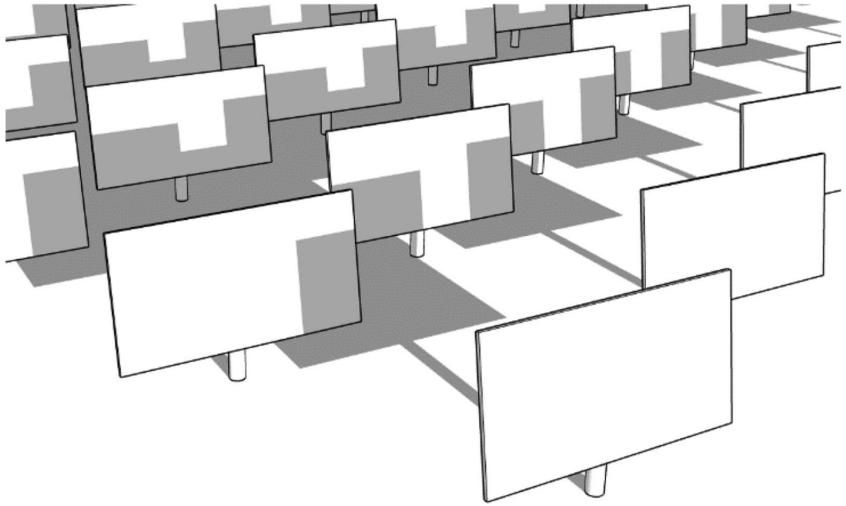


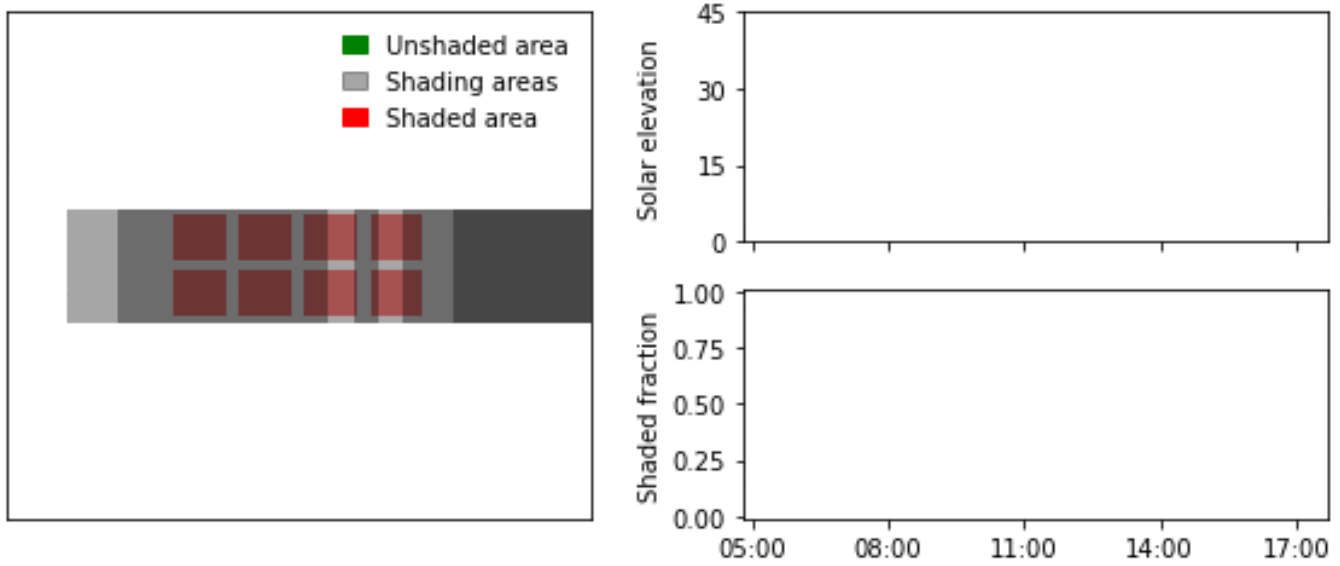
What is pvlib/twoaxistracking?

Shading of two-axis trackers

- Fully customizable field layouts
- Arbitrary panel shape
- Differentiation between active and frame area
- Extensive documentation, validated against literature

Validated against literature!





User's group: pvlib-python, pvanalytics

pvlib-python

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Objectives

1. Communicate what's planned for pvlib-python and pvanalytics
2. Identify and prioritize development ideas
3. Solicit involvement and contributions
4. Stickers!

pvlib python 1.0?

Does 1.0.0 come right after 0.10.*?

- No. Expect 0.11.0 to come next. There is no ETA for pvlib 1.0.0 yet ☺

What does 1.0 mean?

- A declaration that pvlib is no longer “beta” (whatever that means)
- Mostly, no more changes that break people’s code (until 2.0, anyway)

What needs to happen before 1.0?

- Package-wide consistency in naming (mostly there already, but still room for improvement)
- Re-organization of code modules (much has already been done)
- Fill in some modeling gaps: transformer losses, direct shading, etc.
- Rewrite/reorg the docs to follow an intentional strategy instead of the current ad-hoc “pile of info”

New features in development: pvlib-python

Additions/improvements where publications and/or data are available

- ❑ Functions for horizon shading (e.g., input digital elevation data, output angle from ground to horizon) (stalled)
- ❑ Function(s) for LCOE (started, help wanted)
- ❑ Cell, module and string electrical mismatch calculations (started, help wanted)
- ❑ Functions to interchange data with PAN/OND files (started, help needed)

Additions where new publications and/or data may be needed

- ❑ Functions to translate parameters among models:
  - ✓ temperature models
  - ✓ incidence angle modifier (IAM) models
  - ❑ IV curve models
- ❑ Functions to fit models to data: temperature, IV curve and other power models

New features requested: pvlib-python

Additions/improvements where publications and/or data are available

- Degradation of DC components

Additions where new publications and/or data may be needed

- Better models for inverters:
  - Off-unity power factor, temperature derating, MPPT voltage limits, current limits, “smarter clipping”
- Models for DC optimizers, AC transformer losses

What else?

- Features with available references?
- Features needing research before implementation in pvlib?

Improving the user experience: pvlib-python

Overhaul the documentation

- The “middle” layer between the home page for pvlib-python and each function’s document page

Library of data for model benchmarking and comparison

- Non-expert users can be challenged when faced with e.g. seven clear-sky models
- Provide some guide to assist in selecting appropriate models
- Illustrate model accuracy and limitations

More examples (good progress here)

- We want to have examples showing how to use most major features

✓ **More frequent releases (quarterly)**

Quarterly community meetings (contact cwhanse@sandia.gov)

What are your ideas?

pvanalytics

www.github.com/pvlib/pvanalytics.git

Welcoming contributors, developers, maintainers

Project will mature through contact with users

Guiding principles:

- Workflow-independent library of documented functions
  - Many functions have a common signature: input time series, output Boolean series
  - E.g., clear sky labeling, clipped inverters, GHI passes quality checks
- Workflows are higher level objects that combine sequences of functions for common use cases, e.g. performance ratio calculation
  - Prioritize flexibility
  - Classes could help automate workflows
  - Example workflows should help to clarify definitions

Thank You

www.github.com/pvlib/pvlib-python
https://pvlib-python.readthedocs.io

www.github.com/pvlib/pvanalytics
https://pvanalytics.readthedocs.io

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