



ARRAY

Evaluating Software for Terrain-Integrated Modelling of Single-Axis Trackers

Array Technologies

PVPMC 2025, Albuquerque

2025-05-13



Outline

- What is “Terrain-Integrated Modelling”?
- PVSolar 2.0 schema
- Software evaluation summary
- SolarTrack Backtracking gain estimation methodology using SolarFarmer
- SolarFarmer validation
- Enhancing bankability of ARRAY’s trackers, including slope-aware backtracking, diffuse-light optimization, and wind stow behavior

Terrain-Integrated Modelling

Bifacial half-cell
PV modules



Single-axis trackers using "smart" tracking
algorithms on undulating terrain



Custom tracker rotation
angles with sub-hourly
timestamps (e.g., 5 min)



Reasonable simulation
time for sites 100+ MW
(<24 h for annual sims.)



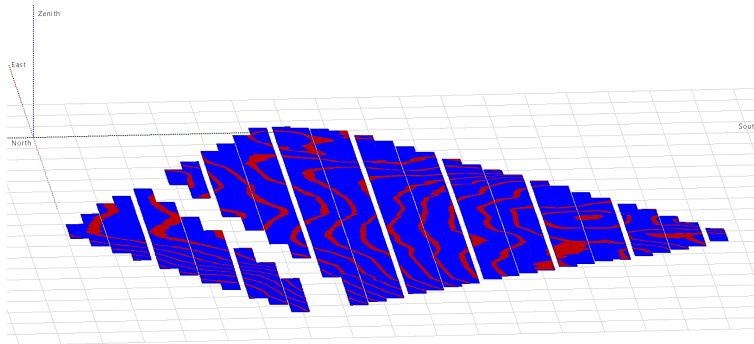
Access to string-level power
calculations in results



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PVCollada (PVC) 2.0 Schema

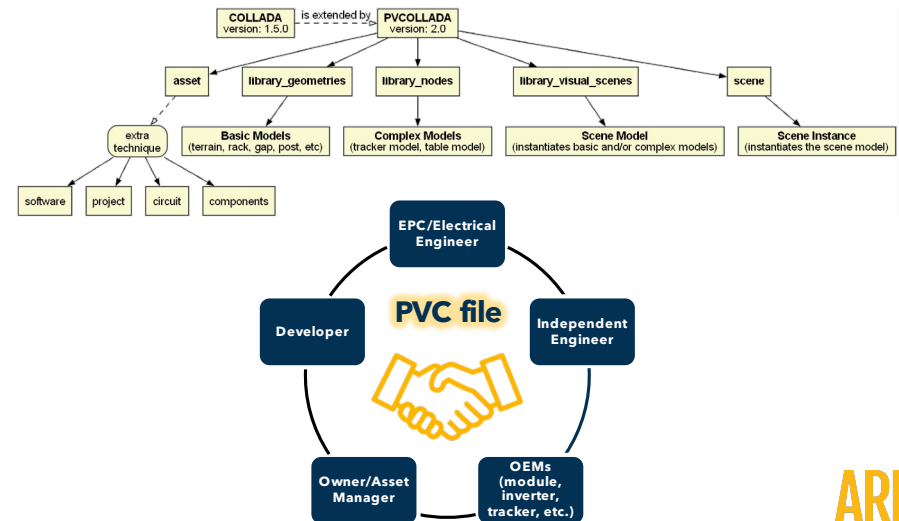
- Cliff Hansen to present on new PVC schema at IEEE PVSC 2025.
- PVCollada began as a standardized XML format for transferring design data from PVCase to PVsyst.
- PVC files are commonly used to describe the shading scene in a PV model, including trackers on terrain and other near-shading objects.



<https://github.com/pvlib/pvcollada>



- PVCollada 2.0 aims to add physical and electrical relationships to the schema—for example, linking strings to trackers and inverters, which could:
 - » Greatly simplify and streamline PV model setup,
 - » Promote greater utilization of site-specific details, and
 - » Allow PV modelling software developers and users to focus on performance modelling details (shading, transposition, mismatch, etc.).



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Software Evaluated

	PVsyst	PlantPredict	SolarFarmer
3D Layout	✓	✓	✓
3D Row-to-Row Shading	✓ Geometric	✓ Geometric (Polygon clipping)	✓ Pixel Counting (Hemicube)
3D Diffuse Shading	✓	Planned	✓
3D Transposition	Specific orientations	Planned	✓
Custom Tracker Angles for 3D Layout		✓	✓
Mismatch Calculation Tied to 3D Shading	✓ Partition approach Detailed (for small systems)	Planned Partition approach	✓ Detailed
Sub-hourly Simulations	Pseudo-sub-hourly simulation	✓	✓
String-level Electrical Calculations Accessible in Output			

References (in addition to publicly available software documentation):

- K. Rhee & J. Spokes, "3D Performance Modeling Made Easy - Introducing PlantPredict v12," PlantPredict Webinar, September 25, 2024.
- M. Olisi et al., "Analysis of electrical shading effects in PV systems," EU PVSEC 2021.
- A. Neubert et al., "Light and Shade - A hemicube approach for efficient shading calculations in utility-scale PV plants," EU PVSEC 2023.

Tracker Import (Step 1)

With PVC

<geometry id = "row_i">
<tracker_parameters>
<axes_vertices>

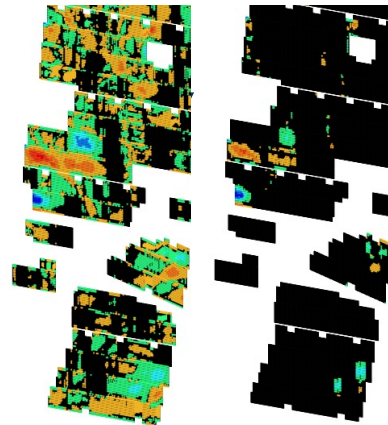


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DuraTrack®

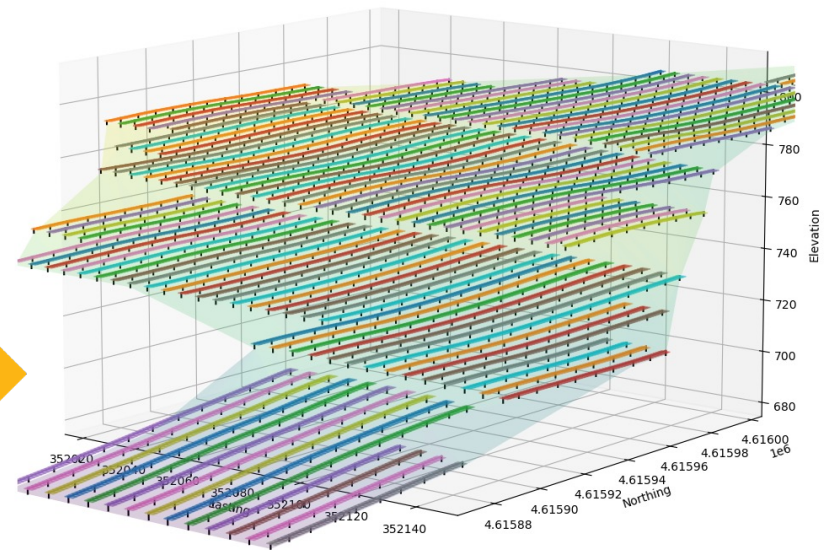
OmniTrack™



~70% grading reduction

Without PVC

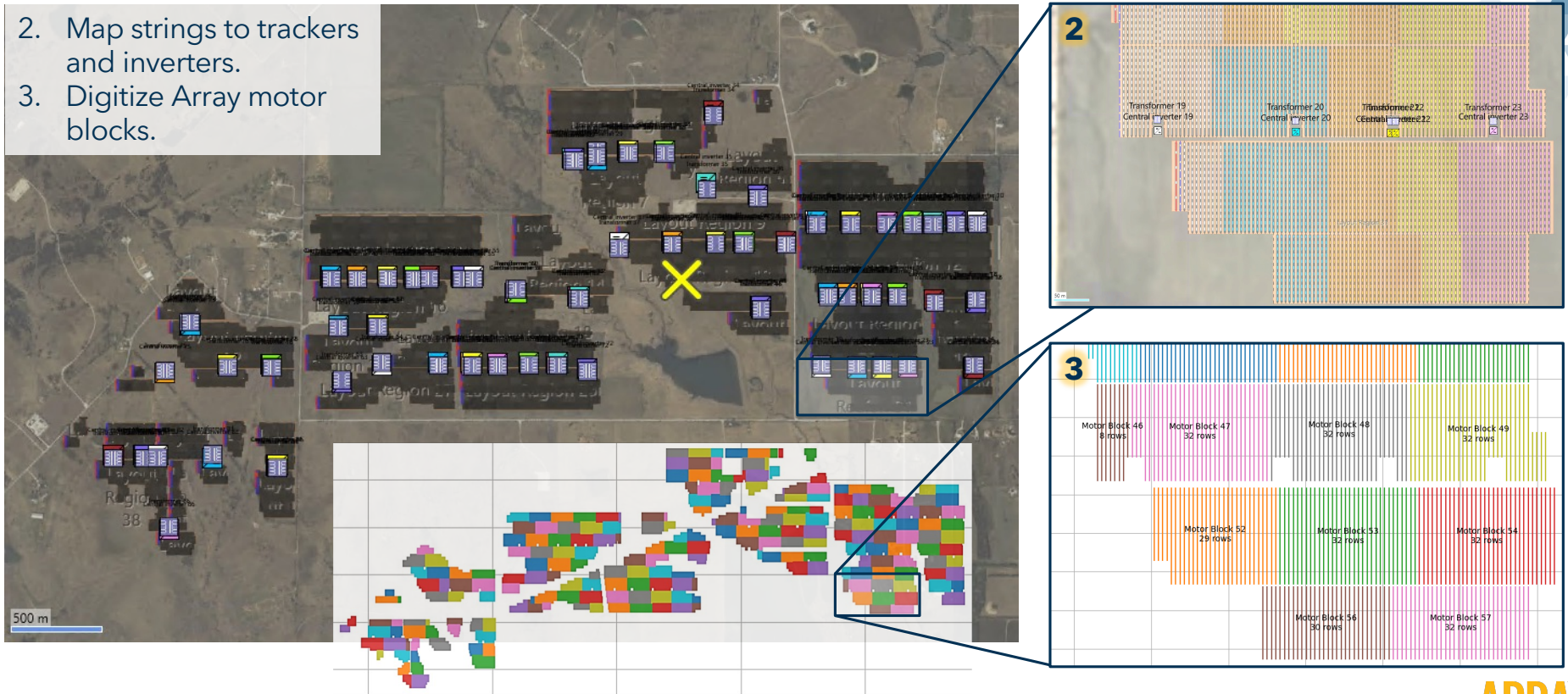
Module Coordinates



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PV Model Setup (Steps 2 & 3)

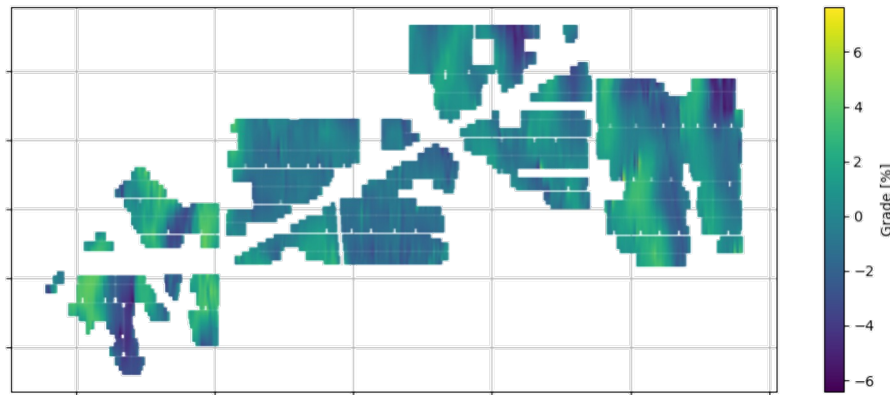
2. Map strings to trackers and inverters.
3. Digitize Array motor blocks.



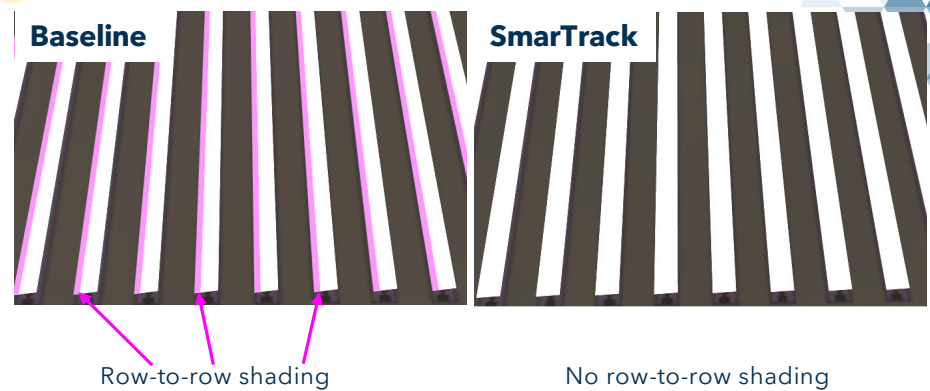
Simulations with Custom Tracker Rotations (Steps 4-6)

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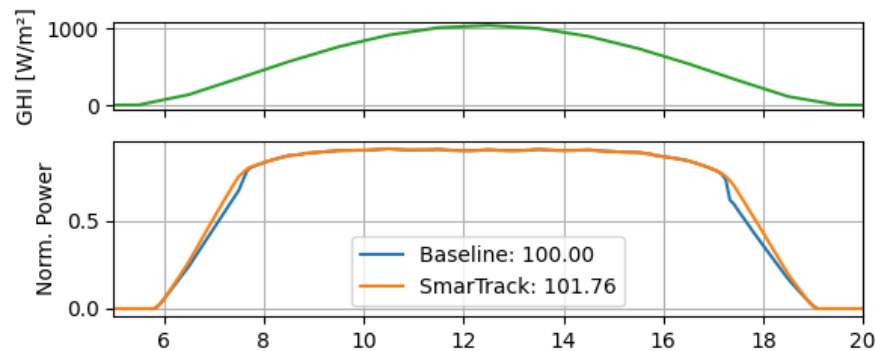
EW Grade



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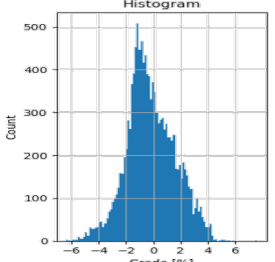
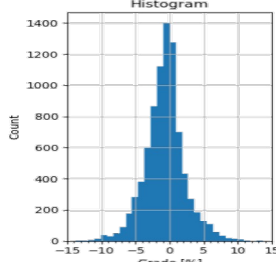
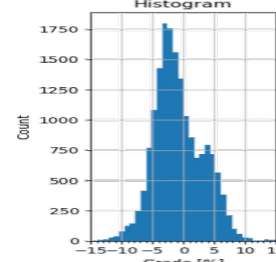
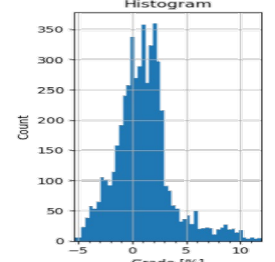


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4. Prepare tracker rotations for Baseline (no optimization) and SmarTrack® cases.
5. Import tracker rotations in SolarFarmer.
6. Run simulation for the two cases with TMY file.

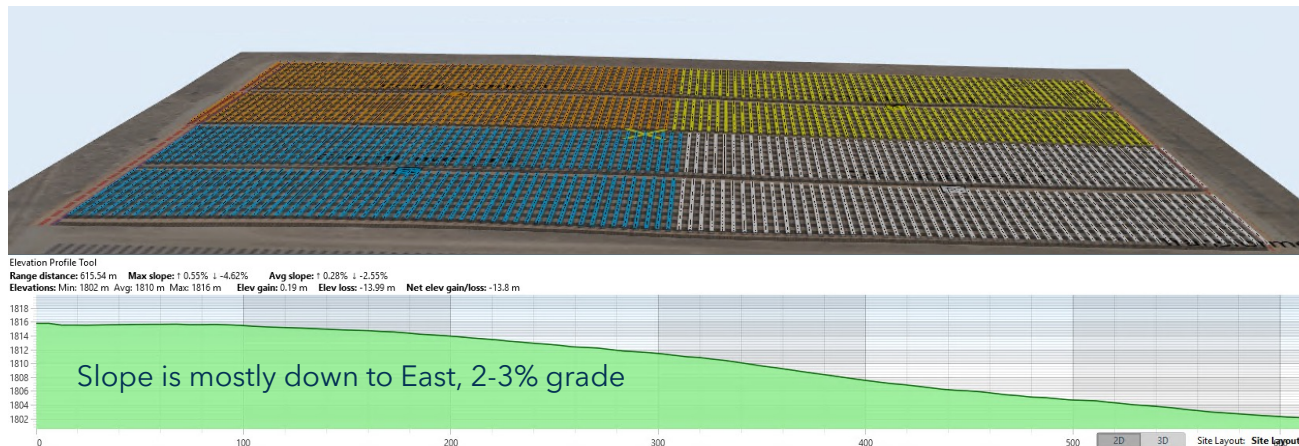
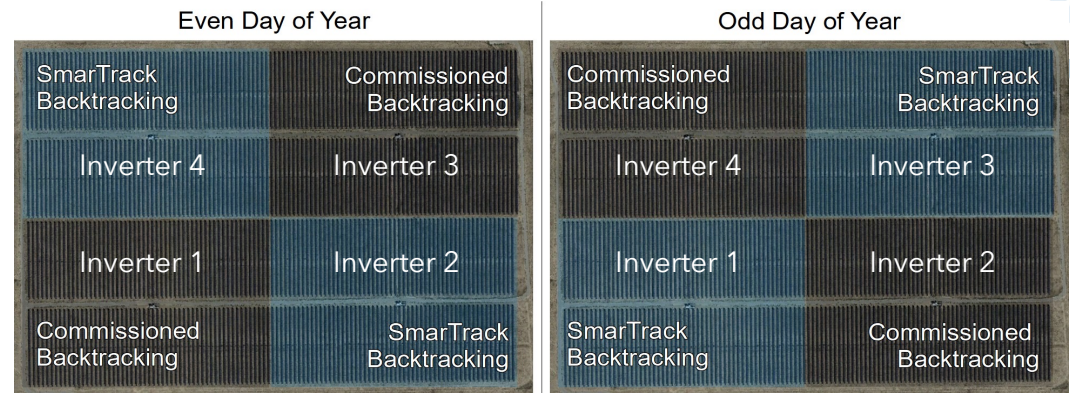
Aggregated SmarTrack Backtracking Gain Estimates

Site	1	2	3	4
Size	~300 MW	~200 MW	~400 MW	~200 MW
Location	Texas, US	Indiana, US	New South Wales, Australia	Anillune, Peru
GCR	40.2%	41.7%	42.5%	30.6%
Diffuse Fraction	35%	41.7% (TMY1) 40.3% (TMY2)	30%	20%
Gain	1.15%	0.88% (TMY1) 0.96% (TMY2)	1.47%	0.44%
EW Grade	Median: -0.37% (down to East) Q1, Q3: -1.35%, 1.01%	Median: -0.59% (down to East) Q1, Q3: -2.28%, 0.79%	Median: -1.39% (down to East) Q1, Q3: -3.50%, 1.89%	Median: 0.93% (down to West) Q1, Q3: -0.55%, 2.26%
				

We can provide hourly multiplication factors to correct PVsyst 8760 output for SmarTrack® gains.

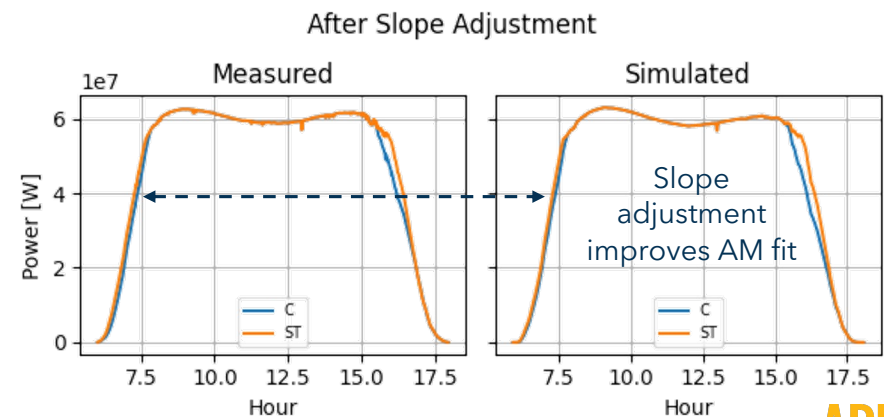
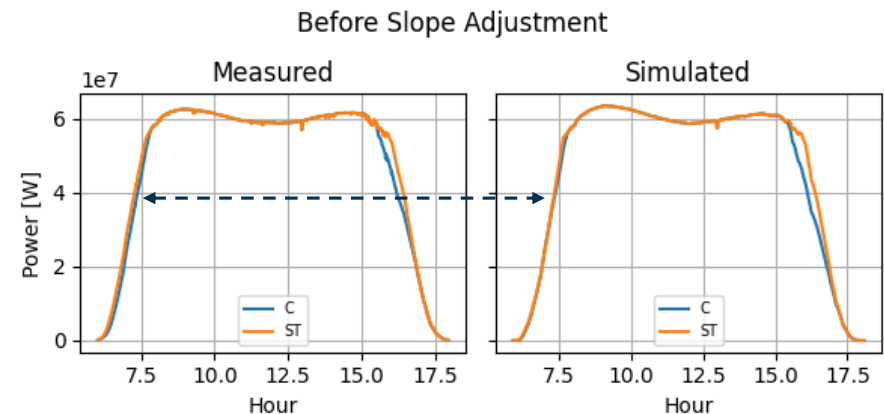
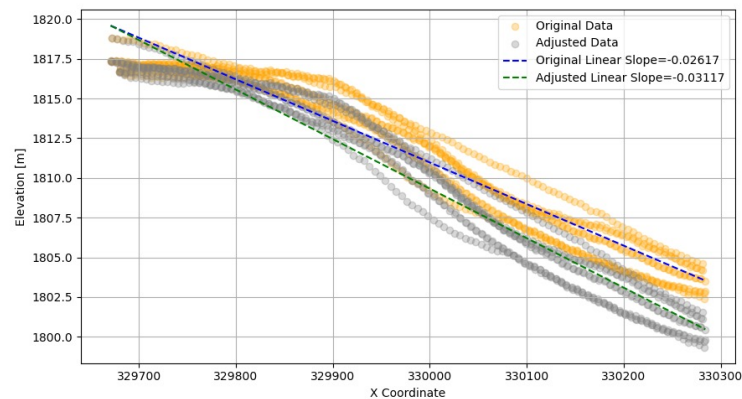
SolarFarmer Validation

- **Site Location:** near Albuquerque, NM, US
- **System Details:** 4 central inverters, 16 ARRAY DuraTrack® motor blocks
- **Testing Details:** 3 backtracking algorithms tested over a 3-week clear-weather period
 1. SmarTrack® (slope aware) vs Commissioned (conventional, GCR tweaked)
 2. SmarTrack® (slope aware) vs Baseline (conventional)
 3. Commissioned (conventional, GCR tweaked) vs Baseline (conventional)
- **Simulation Details:**
 - » Terrain data and measured tracker angles imported directly into SolarFarmer for simulations
 - » Terrain data obtained from Google Elevation API



SolarFarmer Validation Challenges

- 31 simulations to optimize fit to measured data.
- **Terrain data uncertainty**
 - » Google elevation data not expected to accurately represent torque tube elevations due to grading and construction tolerance.
 - » We are seeking on-site terrain measurements (e.g., LiDAR) to reduce this source of uncertainty.



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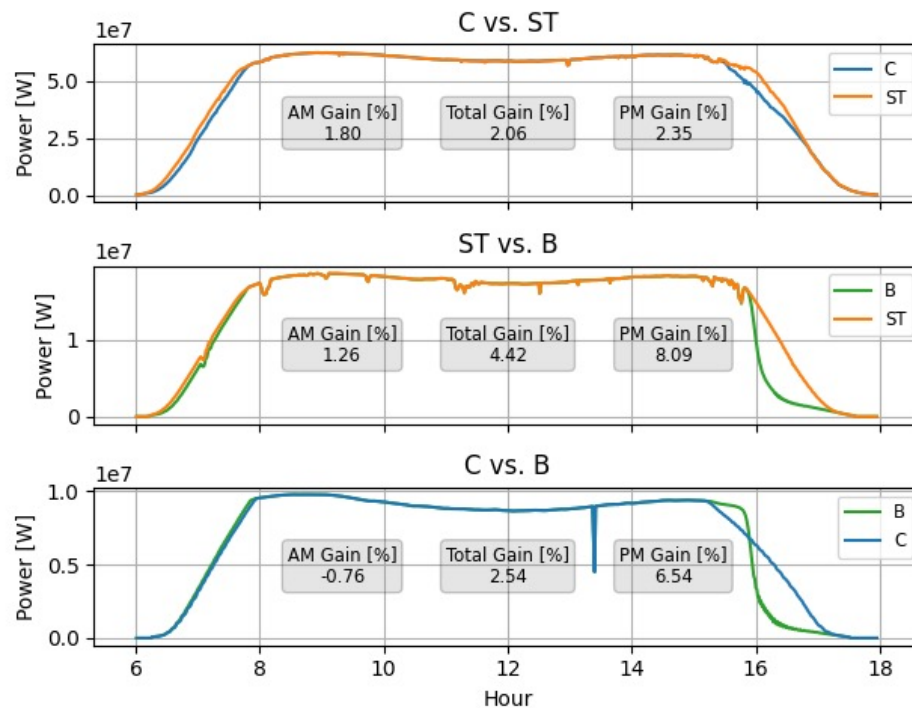
SolarFarmer Validation Results

ST=SmarTrack® (slope aware)

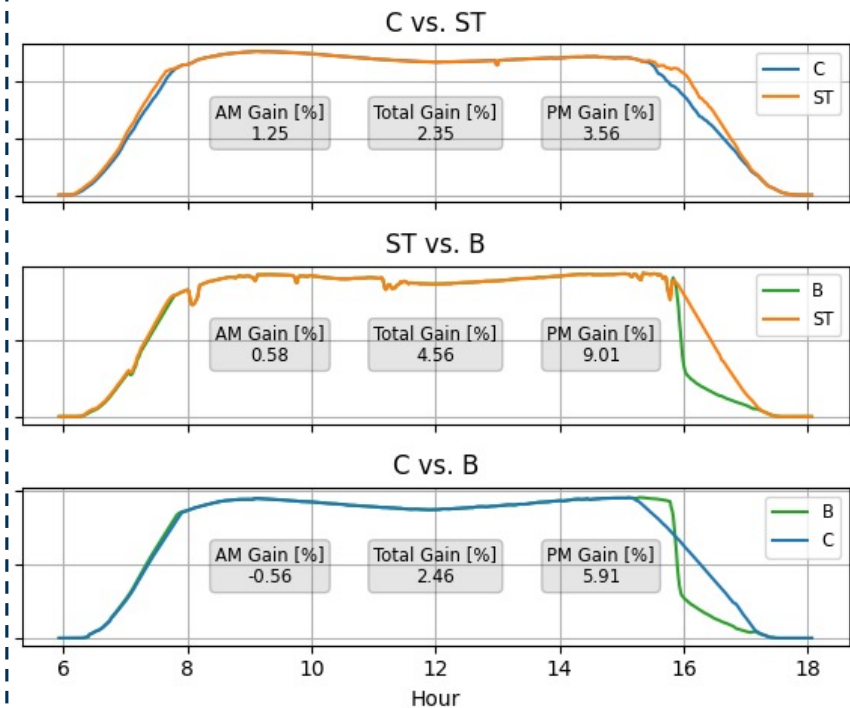
C=Commissioned (conventional, GCR adjusted)

B=Baseline (conventional)

Measured

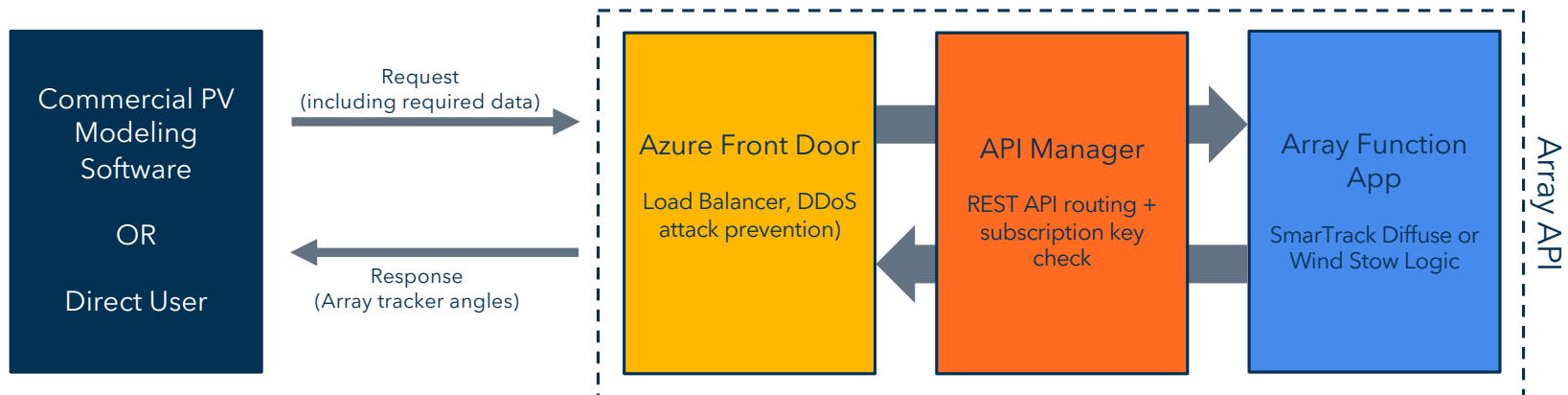
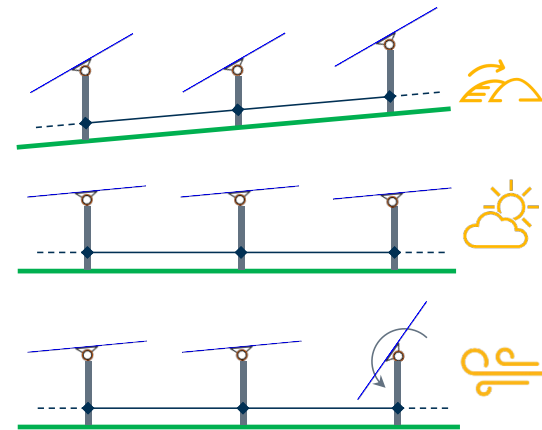


Simulated



Enhancing Bankability

- **SmarTrack® Backtracking**
 - » Array provides shareable 8760 gain estimate files
- **SmarTrack® Diffuse**
 - » Simulation API* implemented in PlantPredict as of September 2024
- **Wind-Stow**
 - » Wind-stow analysis presented by Array's Kendra Conrad at 2024 PVPMC
 - » Simulation API* implemented in PlantPredict as of April 2025



*Email Array.SmarTrack@arraytechinc.com to request an API key (must have NDA in place with Array)

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Thank You

Key Software Features for Terrain-Integrated Modelling of Single-Axis Trackers

3D Layout

3D Row-to-Row Shading

3D Diffuse Shading

3D Transposition

Custom Tracker Angles for 3D Layout

Mismatch Calculation Tied to 3D Shading

Sub-hourly Simulations

String-level Electrical Calculations Accessible in Output

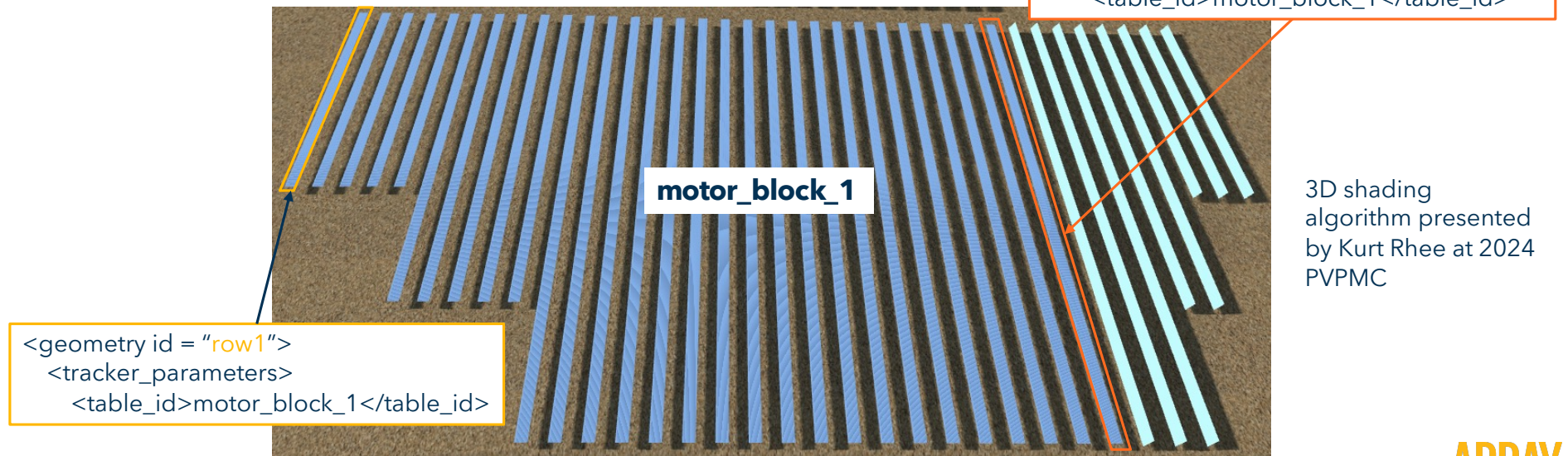
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Supplemental Slides

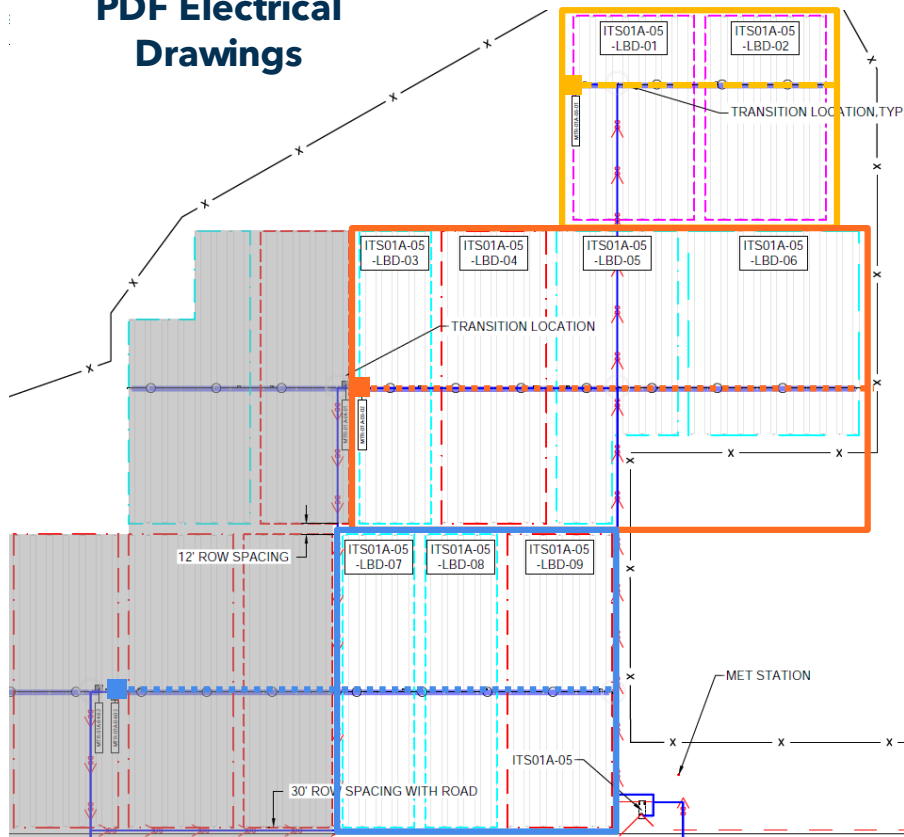
Custom Tracker Rotations: PlantPredict

- As a bridge to PVPollada 2.0, PlantPredict added "<table_id>" sub-elements to the PVC file that allow the user to specify custom tracker rotations for each tracker geometry element ("<geometry id>").
- Trackers with the same rotation angle schedule can use the same table_id, which is convenient for Array motor blocks and can reduce tracker rotation file sizes.
- Automation of PVC modifications can be accomplished with a Python module.



Physical-Electrical Relationships

PDF Electrical Drawings



Digital Map

Combiner	Inverter	Motor
ITS01A-05-LBD-01	ITS01A-05	MTR-01A-05-01
ITS01A-05-LBD-02	ITS01A-05	MTR-01A-05-01
ITS01A-05-LBD-03	ITS01A-05	MTR-01A-05-02
ITS01A-05-LBD-04	ITS01A-05	MTR-01A-05-02
ITS01A-05-LBD-05	ITS01A-05	MTR-01A-05-02
ITS01A-05-LBD-06	ITS01A-05	MTR-01A-05-02
ITS01A-05-LBD-07	ITS01A-05	MTR-01A-04-03
ITS01A-05-LBD-08	ITS01A-05	MTR-01A-04-03
ITS01A-05-LBD-09	ITS01A-05	MTR-01A-04-03

For tracking optimization or detailed PV modelling:

- Trackers must be digitally mapped to combiners and inverters and
- Combiners must be mapped to DC current and voltage measurements at inverter.

SolarFarmer Validation Challenges

- 31 simulations to optimize fit to measured data.
- **GHI sensor tilt off horizontal**
 - » AM-PM asymmetry in simulated production believed to be due to GHI sensor tilt from horizontal.
 - » Tilt correction—using pvlib's `get_total_irradiance` and `gti_dirint` functions—improved fit to measurements.
 - » Using satellite-based irradiance data did not improve the fit.

