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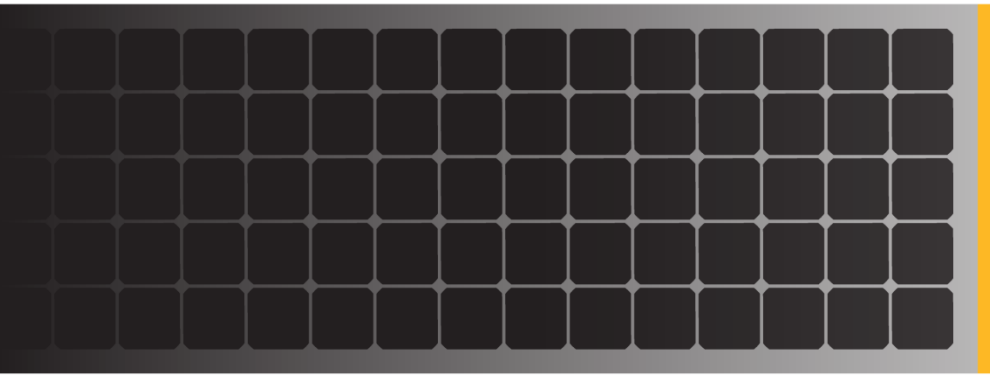

Flexible Methods for Deriving POA Irradiance

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Presented at the 2013 Sandia PV Performance Modeling Workshop
Santa Clara, CA. May 1-2, 2013
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Using & Calculating Irradiance in Simulation Tools

Motivation

- Accuracy and consistency in modeled plane-of-array (POA) irradiance is important for initial and weather-corrected energy models

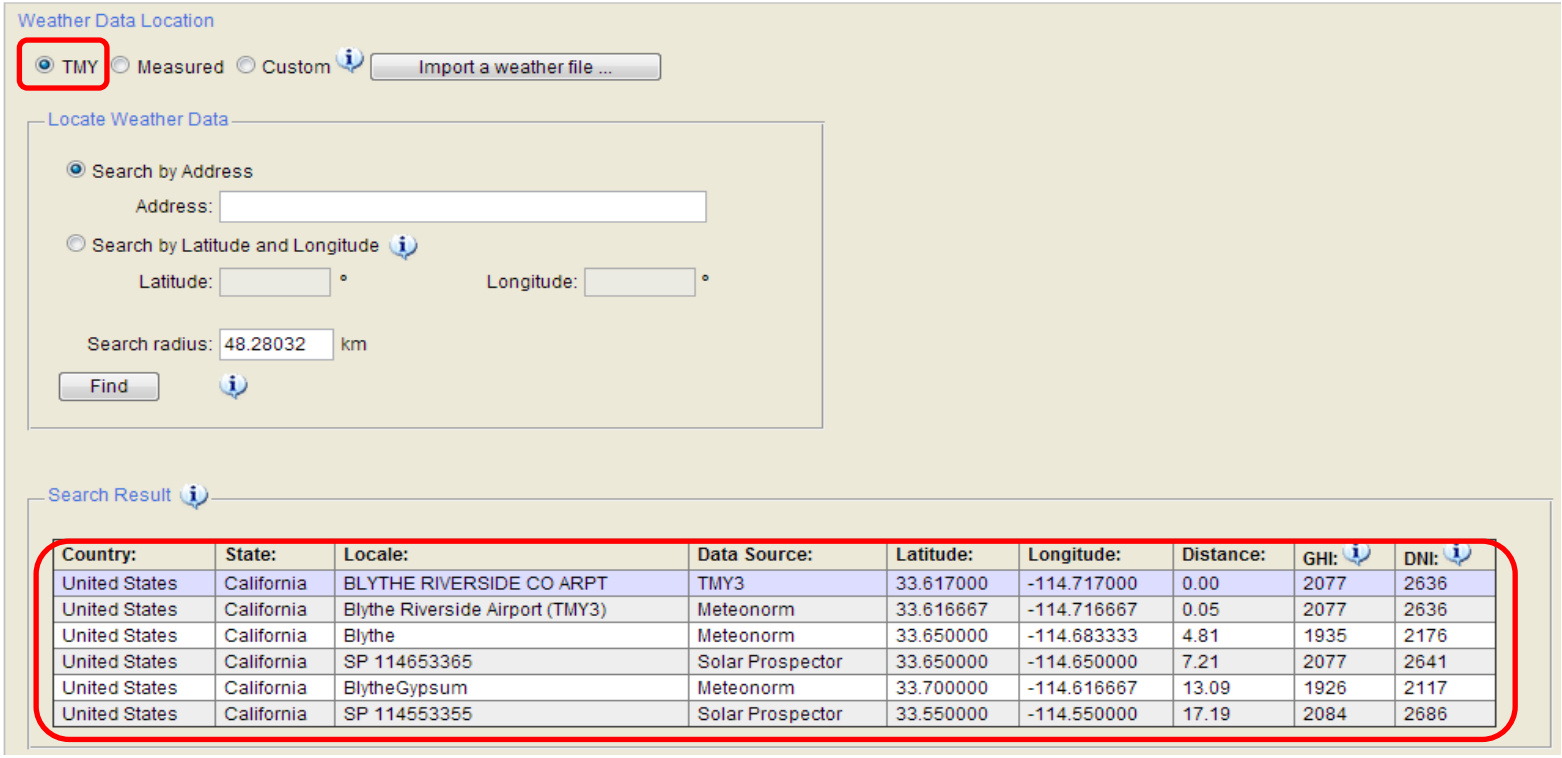
Solution

- Allow flexibility to import and use many combinations of solar resource and meteorological data
- Provide modeling options in simulation tools for use of different irradiance sources
  - GHI only
  - GHI & DNI
  - Tracked reference cell
- Demonstrate the methods

Data Options – TMY, Measured, Custom

TMY Data

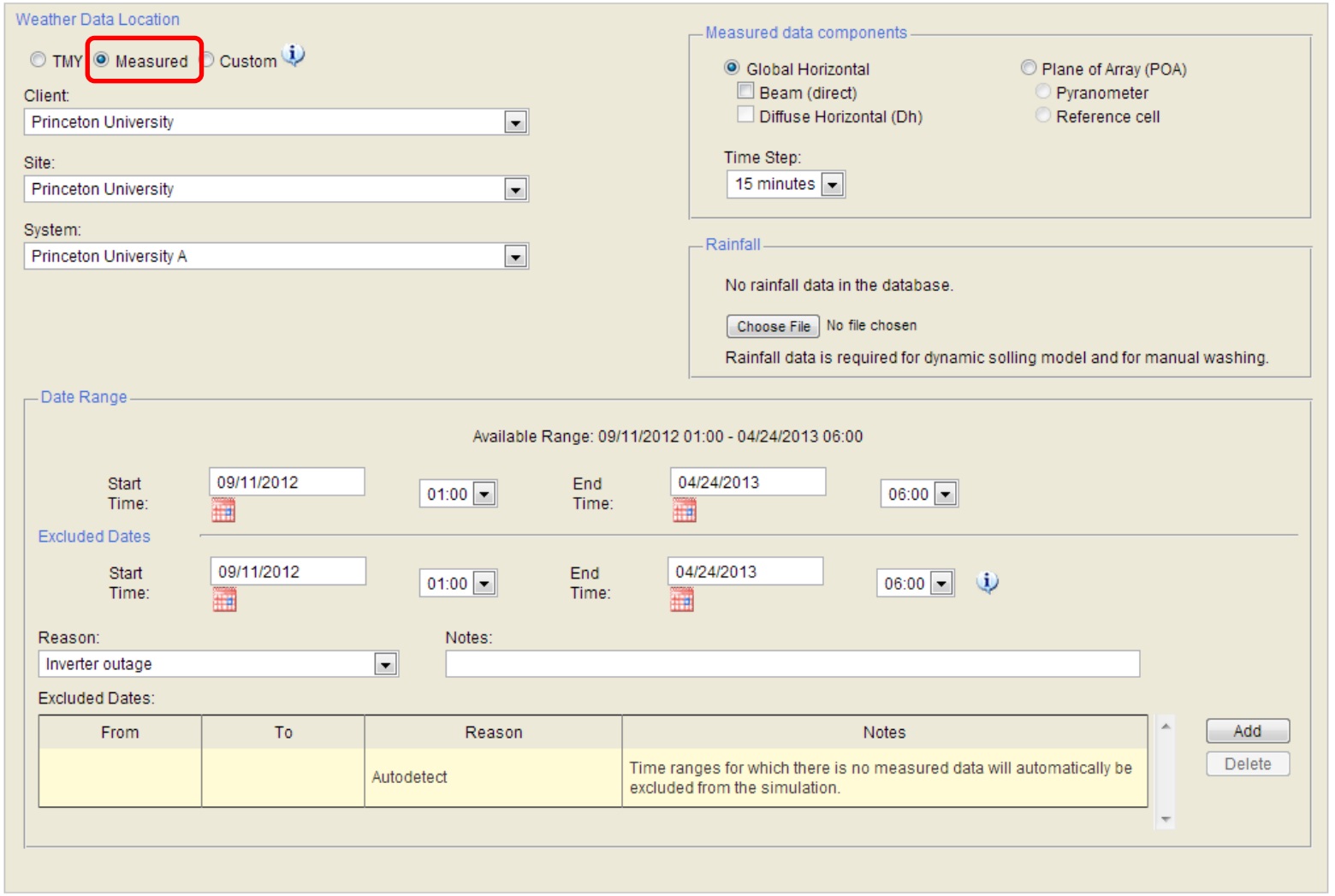
- NREL
  - TMY2/3 – Preloaded data sets (static) → Ready to import “TMY4” when available
  - Solar Prospector - API
  - Meteonorm



Country:	State:	Locale:	Data Source:	Latitude:	Longitude:	Distance:	GHI:	DNI:
United States	California	BLYTHE RIVERSIDE CO ARPT	TMY3	33.617000	-114.717000	0.00	2077	2636
United States	California	Blythe Riverside Airport (TMY3)	Meteonorm	33.616667	-114.716667	0.05	2077	2636
United States	California	Blythe	Meteonorm	33.650000	-114.683333	4.81	1935	2176
United States	California	SP 114653365	Solar Prospector	33.650000	-114.650000	7.21	2077	2641
United States	California	BlytheGypsum	Meteonorm	33.700000	-114.616667	13.09	1926	2117
United States	California	SP 114553355	Solar Prospector	33.550000	-114.550000	17.19	2084	2686

Data Options – TMY, Measured, Custom

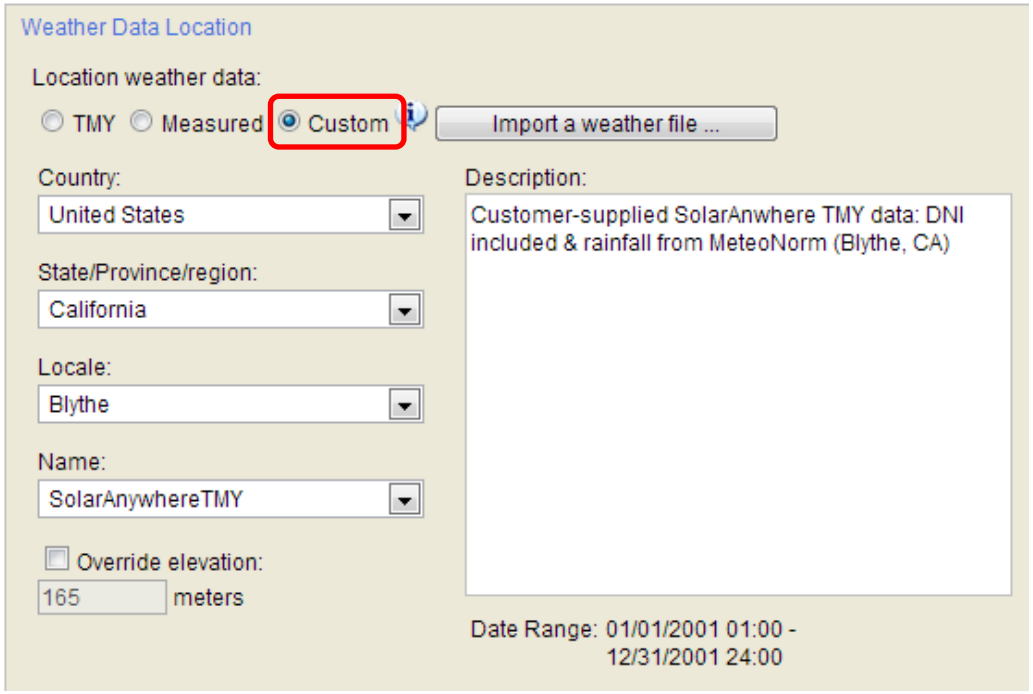
Measured Data from SunPower Commercial Fleet



Data Options – TMY, Measured, Custom

Custom Weather Data

- Non-standard TMY data provided by a customer or third-party solar resource provider
- Single-year measured data (non-TMY)
- Measured met station data



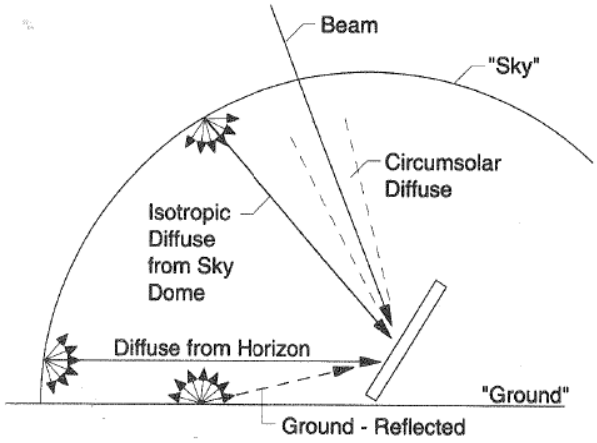
Data Options – TMY, Measured, Custom

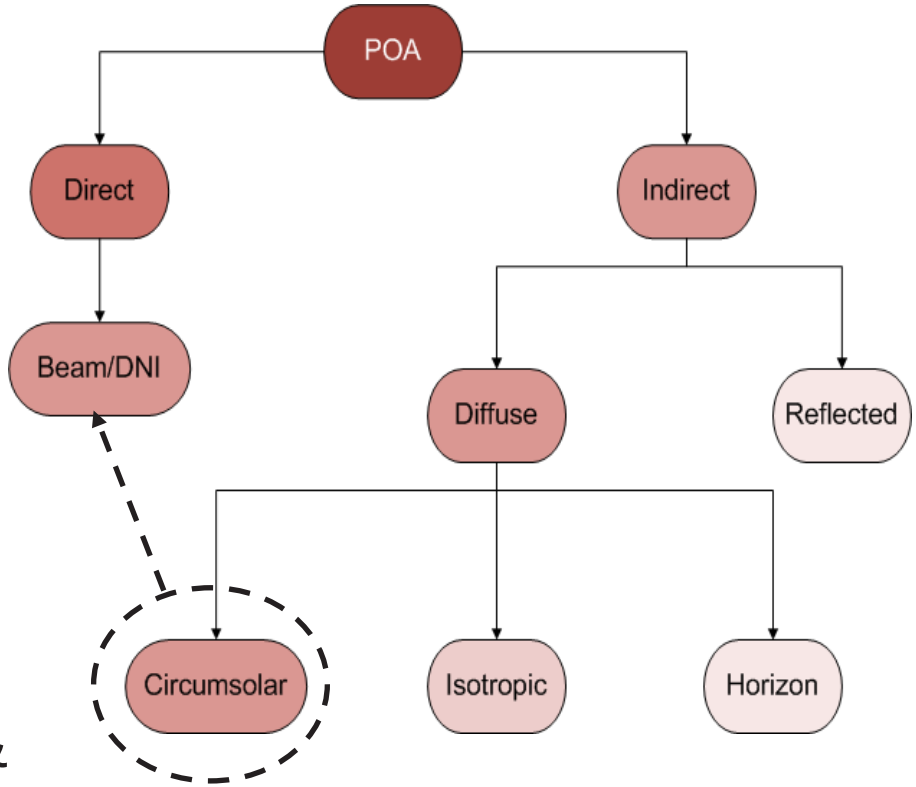
Custom Weather Data – Import Fields & Format

- Flexibility: GHI, DNI, DHI
- Completeness: Ambient Temperature & Wind Speed
- Enhancement: Relative Humidity, Dew Point Temperature, Rainfall

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Name	Locale	State/ Province	Country	Time Zone	Latitude	Longitude	Elevation	Min Tamb	Max Tamb	Anemometer Height	Aggregation Offset	Snapshot Interval	Description	DST	Is Beam Measured
2	<Descriptor>	<City>	<State>	<Country>	<TimeZone>	<Lat>	<Long>	<Elevation>			10	0	3600	<Description>	No	No
3	Time-stamp	Tamb	GHI	POA	WS	Wdir	RH	DNI	DHI	Rainfall	Tdew					
4	1/1/2007 1:00	0.0	0.0		0.0	0	0.0	0.0								
5	1/1/2007 2:00	-18.1	0.0		1.5	151	97.8	0.0								
6	1/1/2007 3:00	-18.5	0.0		1.9	113	100.0	0.0								
7	1/1/2007 4:00	-21.7	0.0		1.5	33	66.7	0.0								
8	1/1/2007 5:00	-22.8	0.0		1.5	33	66.7	0.0								
9	1/1/2007 6:00	-21.5	0.0		1.5	33	66.7	0.0								
10	1/1/2007 7:00	-21.5	0.0		1.5	33	66.7	0.0								
11	1/1/2007 8:00	-21.4	0.0		1.5	33	66.7	0.0								
12	1/1/2007 9:00	-16.7	0.0		4.0	-23	73.4	0.0								
13	1/1/2007 10:00	-21.4	99.7		2.3	13	96.8	367.9								
14	1/1/2007 11:00	-19.3	241.7		2.0	81	81.8	630.6								
15	1/1/2007 12:00	-15.8	347.6		1.6	44	69.0	730.7								
16	1/1/2007 13:00	-13.6	405.4		2.4	-6	71.9	768.8								
17	1/1/2007 14:00	-12.6	402.7		1.8	-6	79.4	755.4								
18	1/1/2007 15:00	-12.7	318.0		1.3	3	80.0	636.0								
19	1/1/2007 16:00	-14.2	200.2		2.3	-10	88.1	460.9								
20	1/1/2007 17:00	-16.9	81.1		2.2	-22	100.0	206.1								
21	1/1/2007 18:00	-19.9	0.0		2.8	-27	100.0	0.0								
22	1/1/2007 19:00	-21.1	0.0		2.7	-16	100.0	0.0								
23	1/1/2007 20:00	-21.3	0.0		1.9	17	88.3	0.0								
24	1/1/2007 21:00	-21.6	0.0		2.2	45	87.1	0.0								
25	1/1/2007 22:00	-21.3	0.0		2.3	-1	90.2	0.0								

Procedure for Calculating POA Irradiance





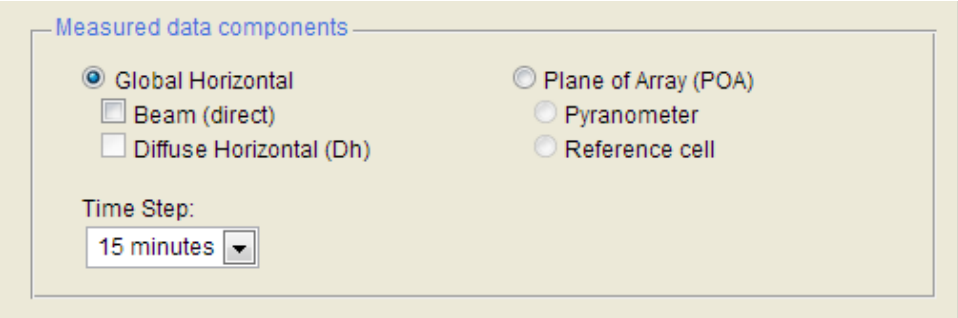
1. Calculate DNI (Perez DIRINT & DIRINDEX models)
2. Calculate DHI from GHI & DNI
3. Decompose DHI into diffuse components
4. Transpose & aggregate individual components onto the plane of the array surface (I_{POA})

SPWR uses Perez DNI Model in PVSim – *Why?*

Demonstrated accuracy of calculated POA irradiance

Flexibility when

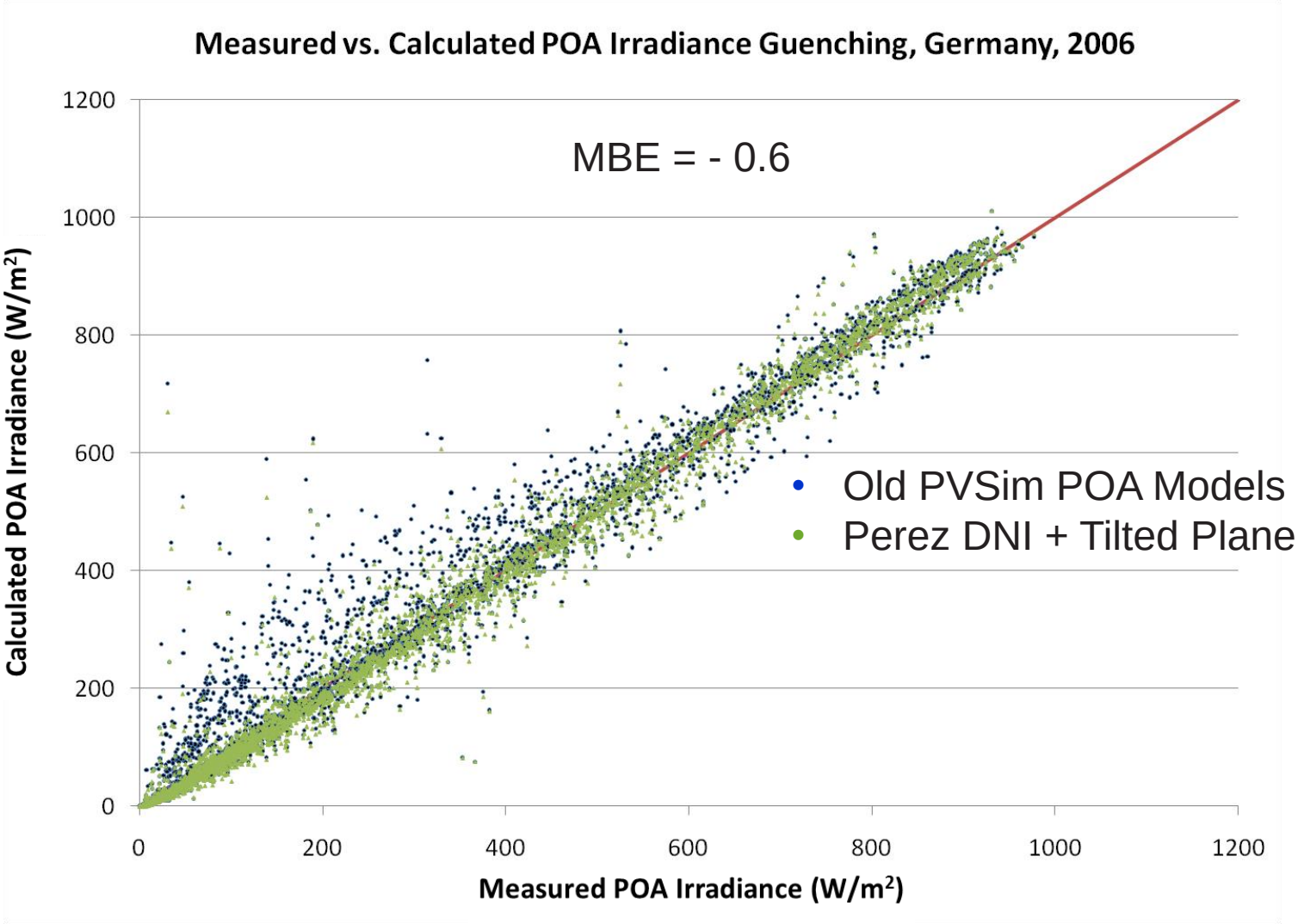
- DNI is not available in the data set
- Poor quality DNI/DHI data
- Timestamp errors exist between GHI and DNI/DHI



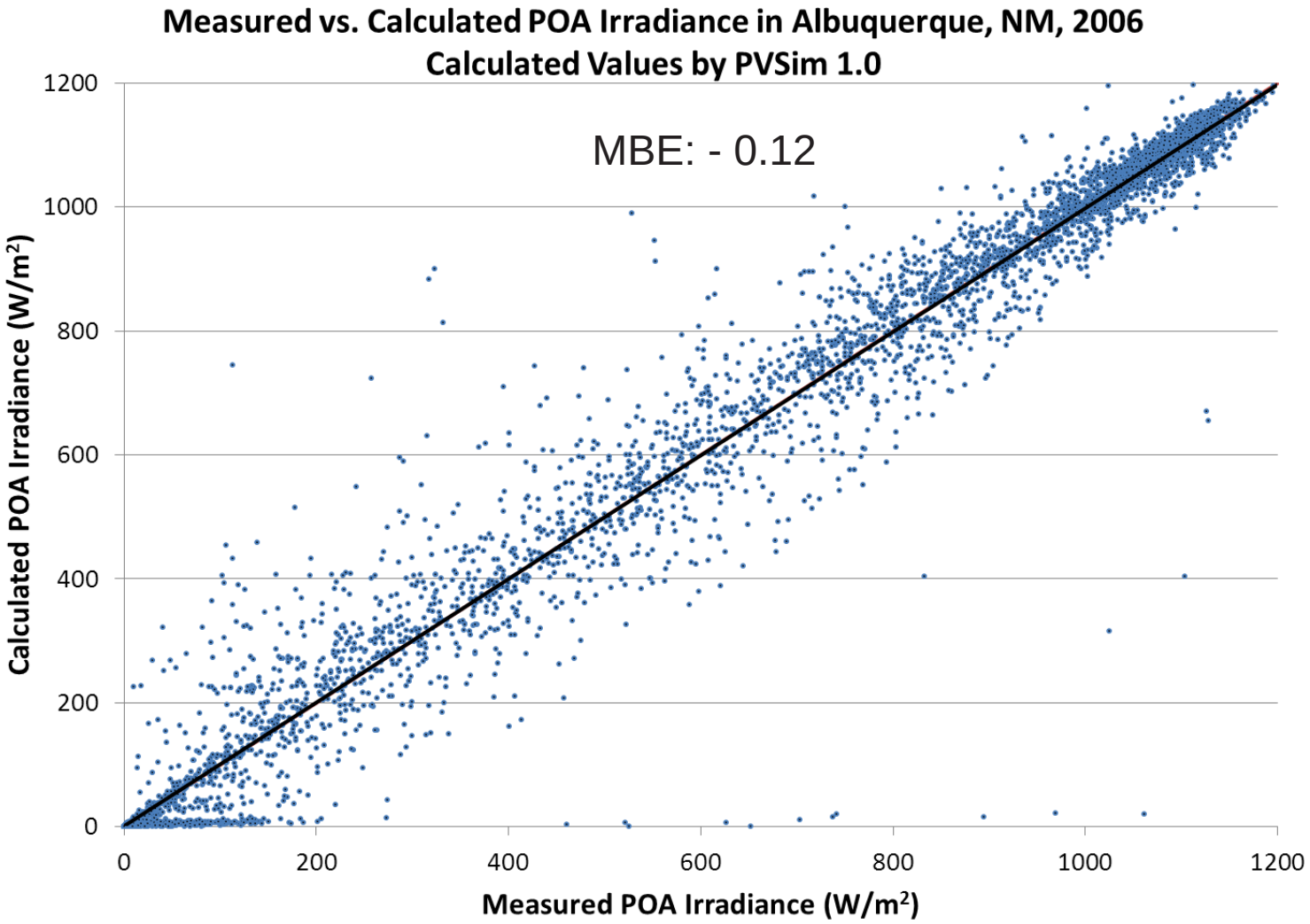
Consistency

- Consistent methods across all data sources (TMY, measured, etc.)
- Prediction-to-Test: weather-correction model consistent with energy prediction model

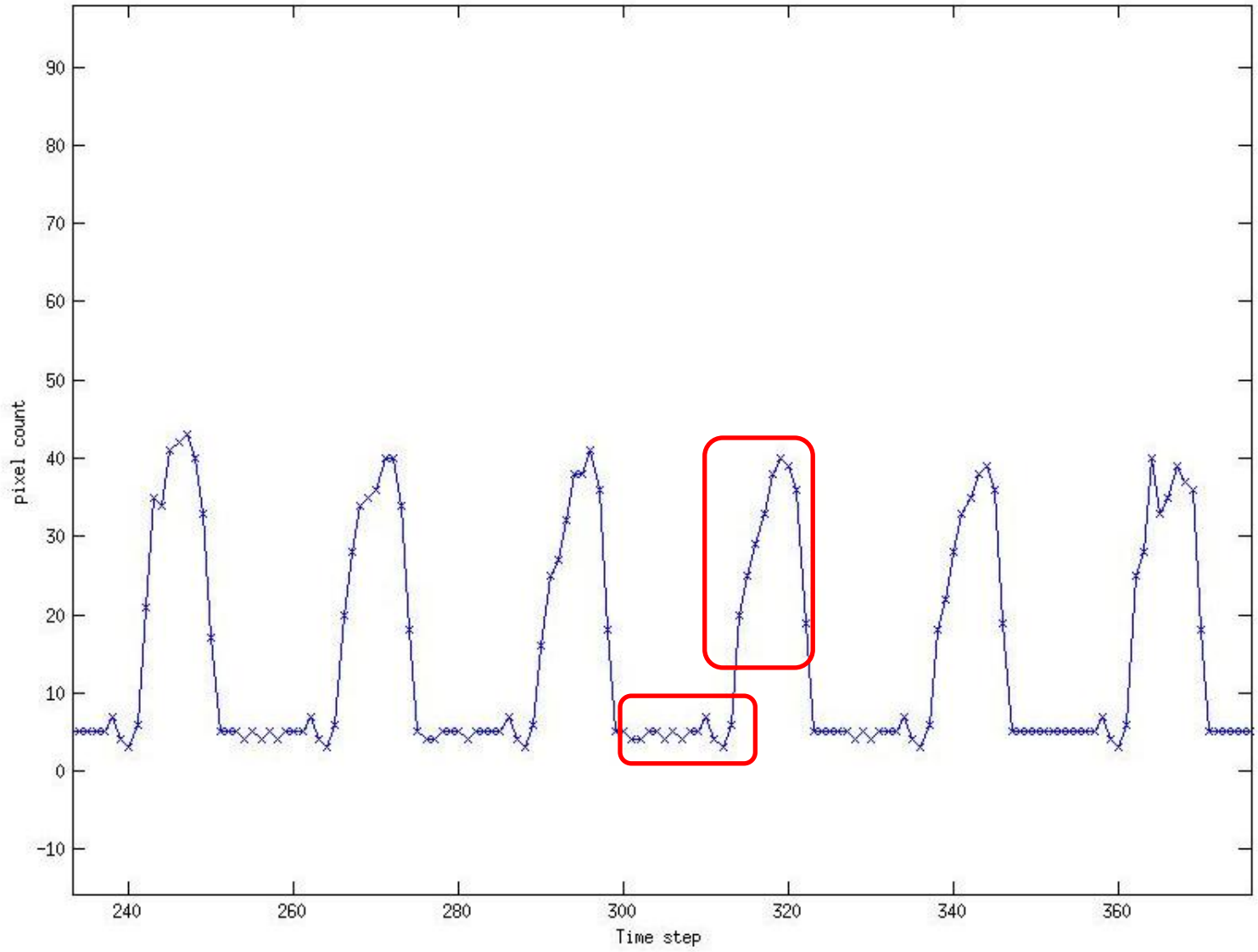
POA Accuracy – Diffuse Climate



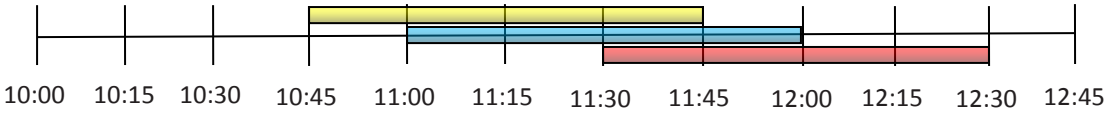
POA Accuracy – High DNI Climate



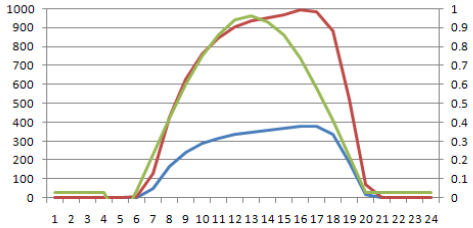
Flexibility – Poor Quality DNI Data



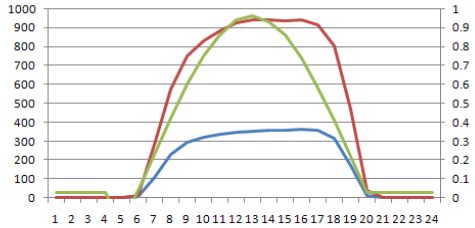
Flexibility – Correcting Data Aggregation Errors



Start Time of Aggregation: 10:45



Start Time of Aggregation: 11:00



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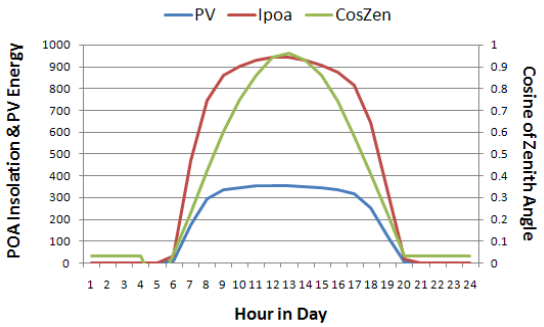

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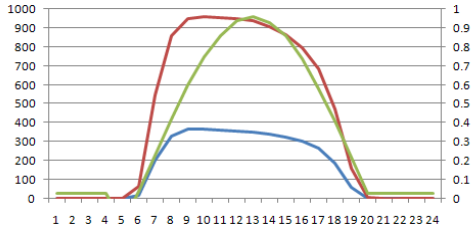

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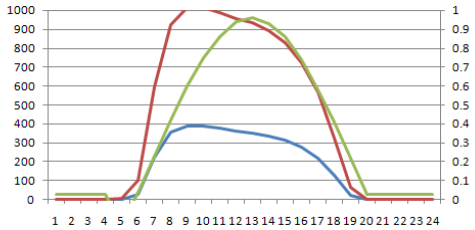


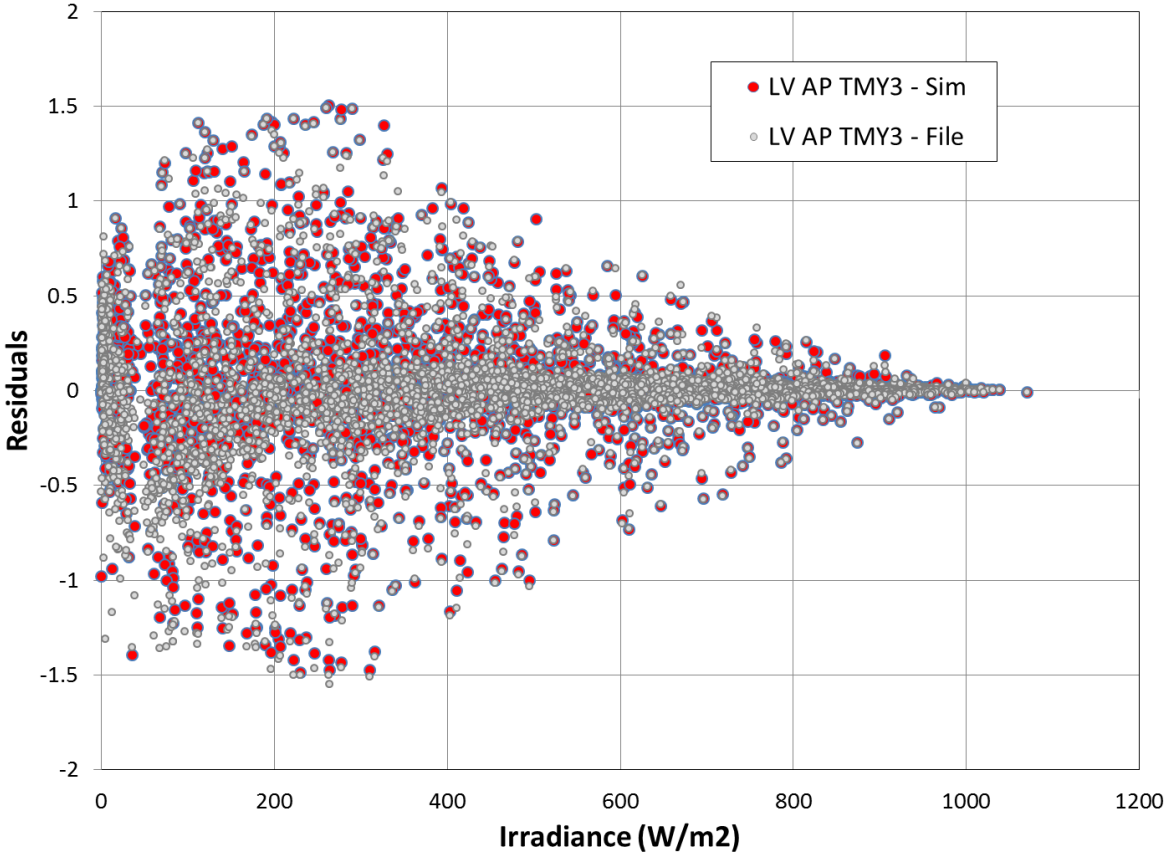
Consistency Across Data Sources

Metric:

- **$P = [POA/GHI]_i$**

Residual:

- **$R = P_{WC} – P_{TMY}$**
- **P_{WC} = weather corrected**
- **P_{TMY} = original model**



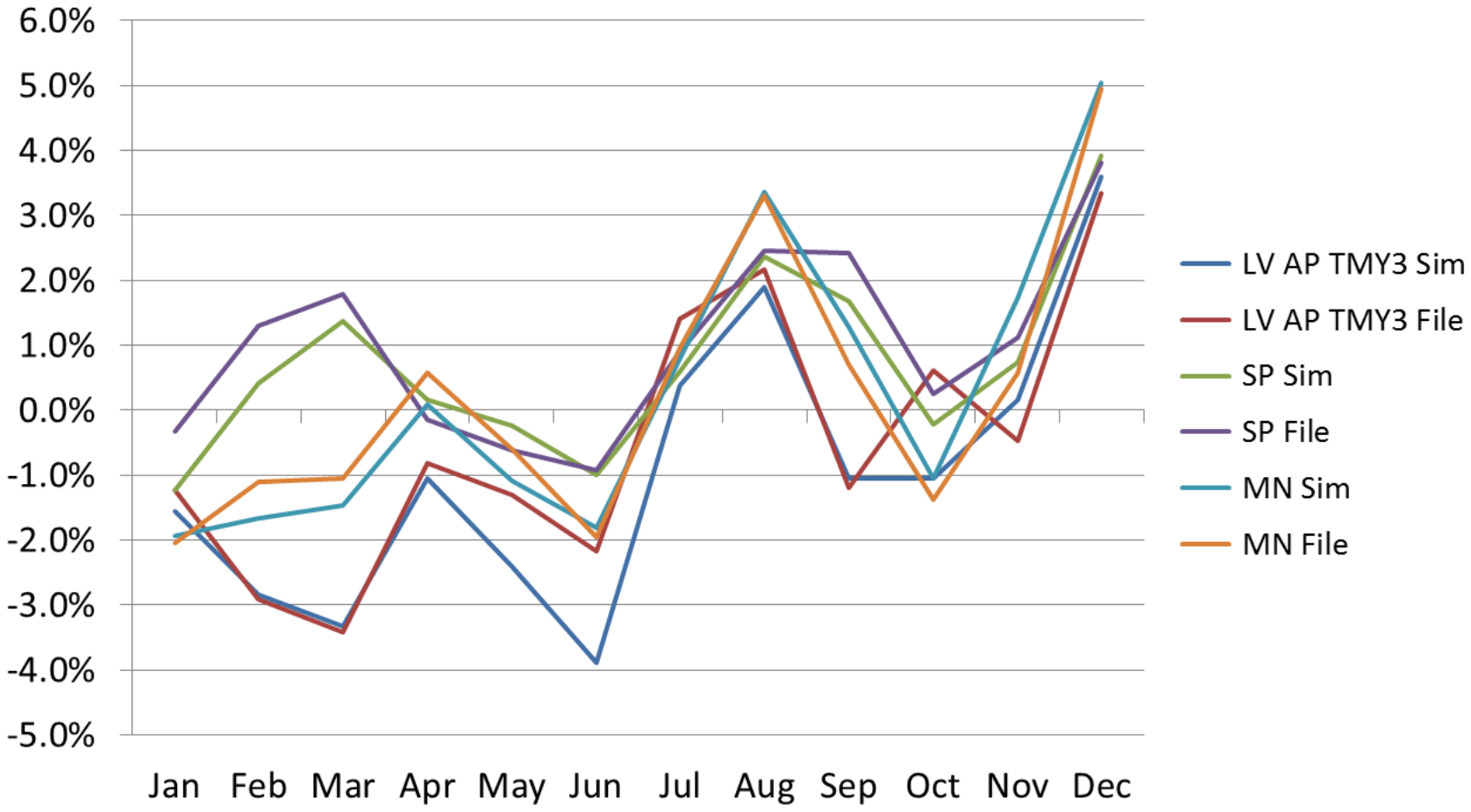
Residuals analysis demonstrates

- consistency between PVSim implementation of Perez Model and models used to generate TMY data, and/or
- insensitivity of POA to differences in sky models

Consistency Across Data Sources

Monthly variability in model accuracy

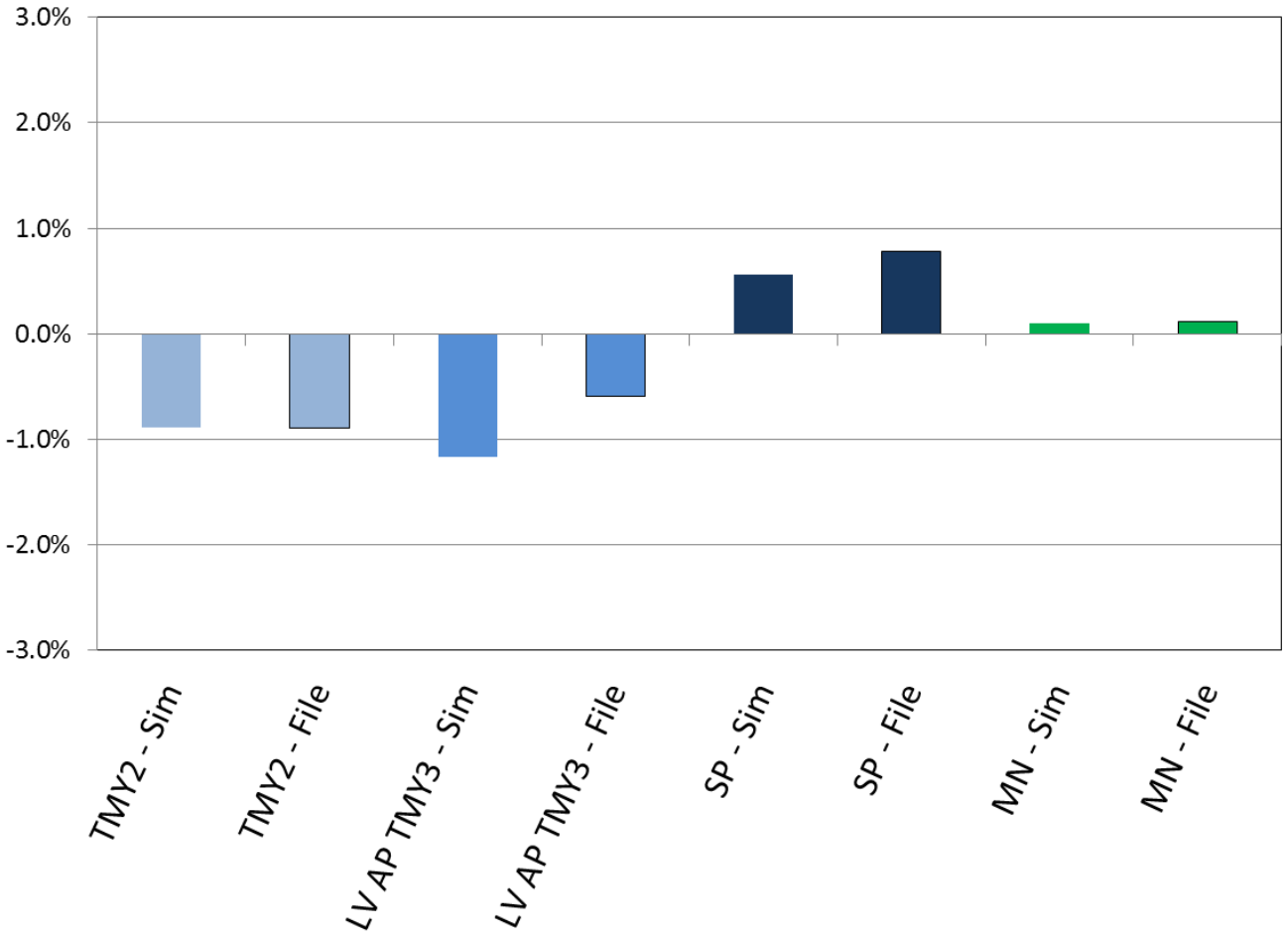
- Monthly residual totals



Consistency Across Data Sources

Monthly variability in model accuracy

- Annual transposition factor relative to measured (POA/GHI)



Conclusions

Integration of irradiance models in PV simulation tools provides flexibility to overcome

- Lack of available DNI data
- Data quality issues

Integrated irradiance models provide consistency in POA calculations across TMY and site-measured data

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