



NREL and Sandia Photovoltaic (PV) Workshop
The Use of Shadowband Radiometer Data to Reduce POA Uncertainty
Justin Robinson
February 27, 2015



Use of RSR2 DHI for POA Modeling

Can measured RSR2 DHI reduce modeled POA uncertainty?

Solar community split

Concerns about measurement bias

PV developers struggle with mismatched datasets

Studies show that LI200 underestimate DHI by 20-30%

Limited characterization beyond NREL SRRL





Solar Resource Assessment Methodology

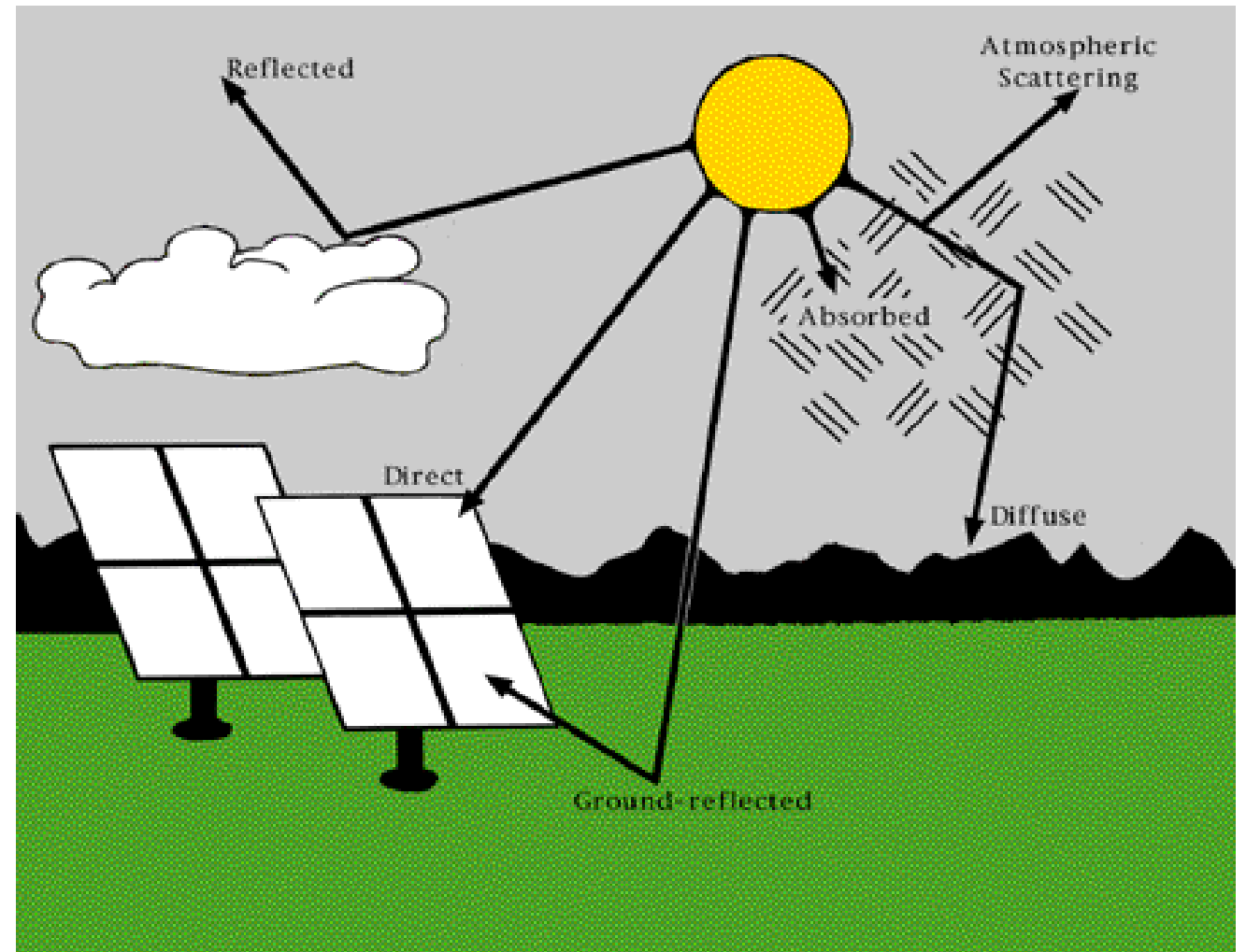
Collect one year or more high quality ground based GHI

Tune satellite data with high quality ground based GHI

Model POA with tuned GHI

Use decomposition algorithm or measured DHI (predominantly RSR2)





<http://rredc.nrel.gov>

Decomposition Model Studies

Gueymard and Ruiz-Arias, 2014

“ an obvious conclusion is that a more efficient and truly “universal” model is necessary.”

Lave et al., 2015

Evaluation of GHI Irradiance to POA Irradiance Models at Locations Across the United States.

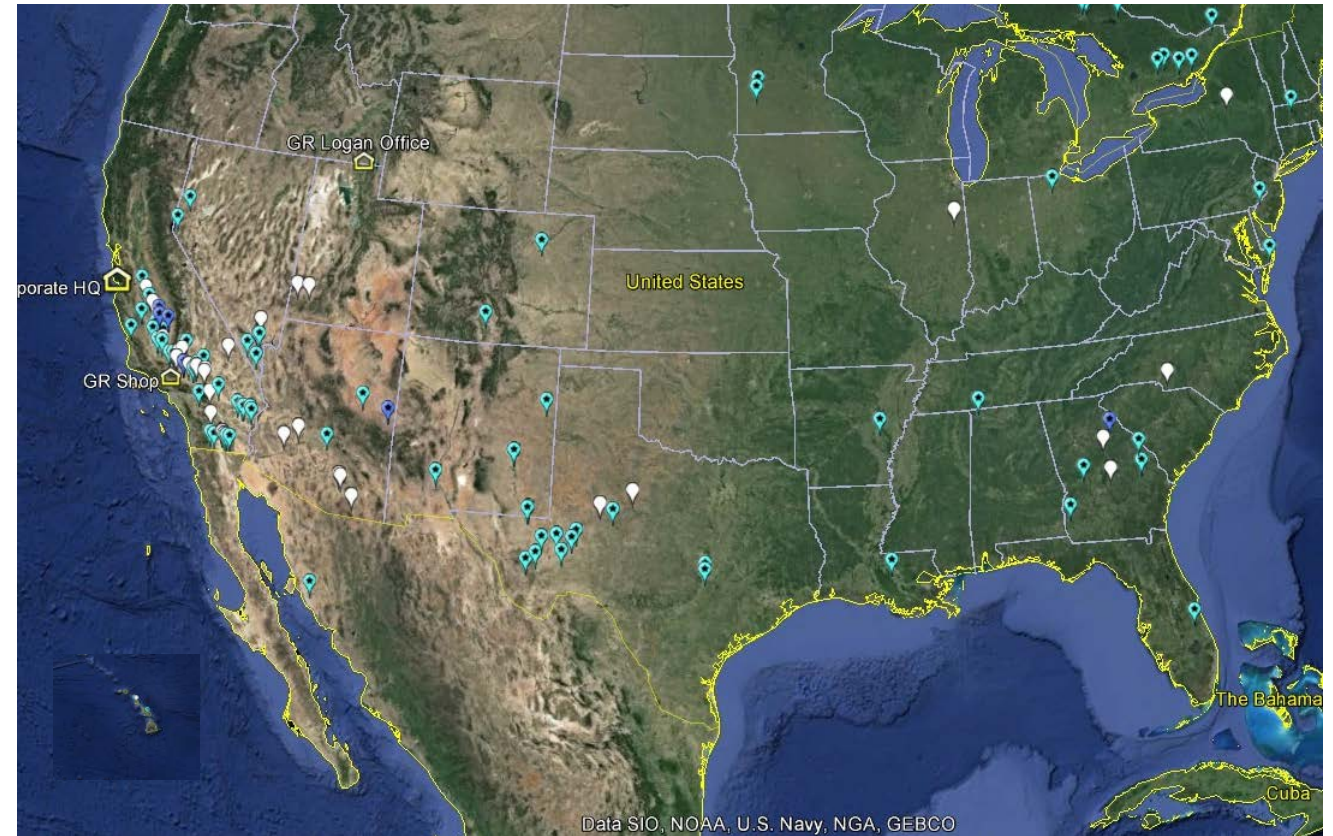


Decomposition Models Performance Statistics

Table 3. Summary performance statistics (in percent of the overall mean DNI, 662.4 W/m²) for all 36 tested models at all test sites combined. Best results in each category are in bold; best results overall are in bold italic and underlined.

Acronym	#Predictors	MBD	RMSD	MAD	Acronym	#Predictors	MBD	RMSD	MAD
BOLAND1	1	0.6	18.0	12.5	GONZALEZ	2	0.2	16.0	11.9
DEMIGUEL	1	-2.0	17.0	13.1	HELBIG	2	<u>0.0</u>	16.0	11.6
ERBS	1	-0.6	16.9	12.5	HOLLANDS2	2	-3.6	21.4	15.3
HOLLANDS1	1	2.0	18.7	12.6	MACAGNAN	2	1.2	18.6	14.1
LAM	1	-8.3	21.2	18.3	MAXWELL	2	4.3	15.6	10.6
LI	1	-4.9	18.6	15.4	POSADILLO	2	5.7	17.8	12.4
LOUCHE	1	5.0	17.4	11.4	REINDL2	2	-4.9	17.7	14.0
MONDOL	1	-7.7	18.8	16.0	RIDLEY1	2	-0.4	18.8	12.8
MORENO	1	6.7	19.3	13.0	RUIZARIAS2	2	-1.9	18.1	14.0
MUNEER	1	-4.7	17.9	14.1	SKARTVEIT1	2	-4.5	16.3	13.2
OLIVEIRA	1	0.2	17.2	13.0	STAUTER	2	-5.8	19.0	15.3
REINDL1	1	-0.4	16.9	12.5	SUEHRKE	2	-2.7	15.7	11.2
RUIZARIAS1	1	4.7	18.3	12.2	ZHANG	2	3.5	17.4	11.3
SANCHEZ	1	6.1	18.0	12.4	SKARTVEIT2	3	-3.9	16.5	12.6
TORRES1	1	-1.5	17.3	13.7	PEREZ1	4	5.3	14.7	9.7
TORRES2	1	-0.2	17.1	13.1	REINDL3	4	-0.4	<u>12.5</u>	9.5
					BOLAND2	5	1.4	15.8	11.0
					LAURET	5	4.3	17.4	11.3
					RIDLEY2	5	4.9	16.5	10.5
					PEREZ2	6	2.1	13.8	<u>9.3</u>





RSR2 Prevalence

Over 800 units sold since 1991

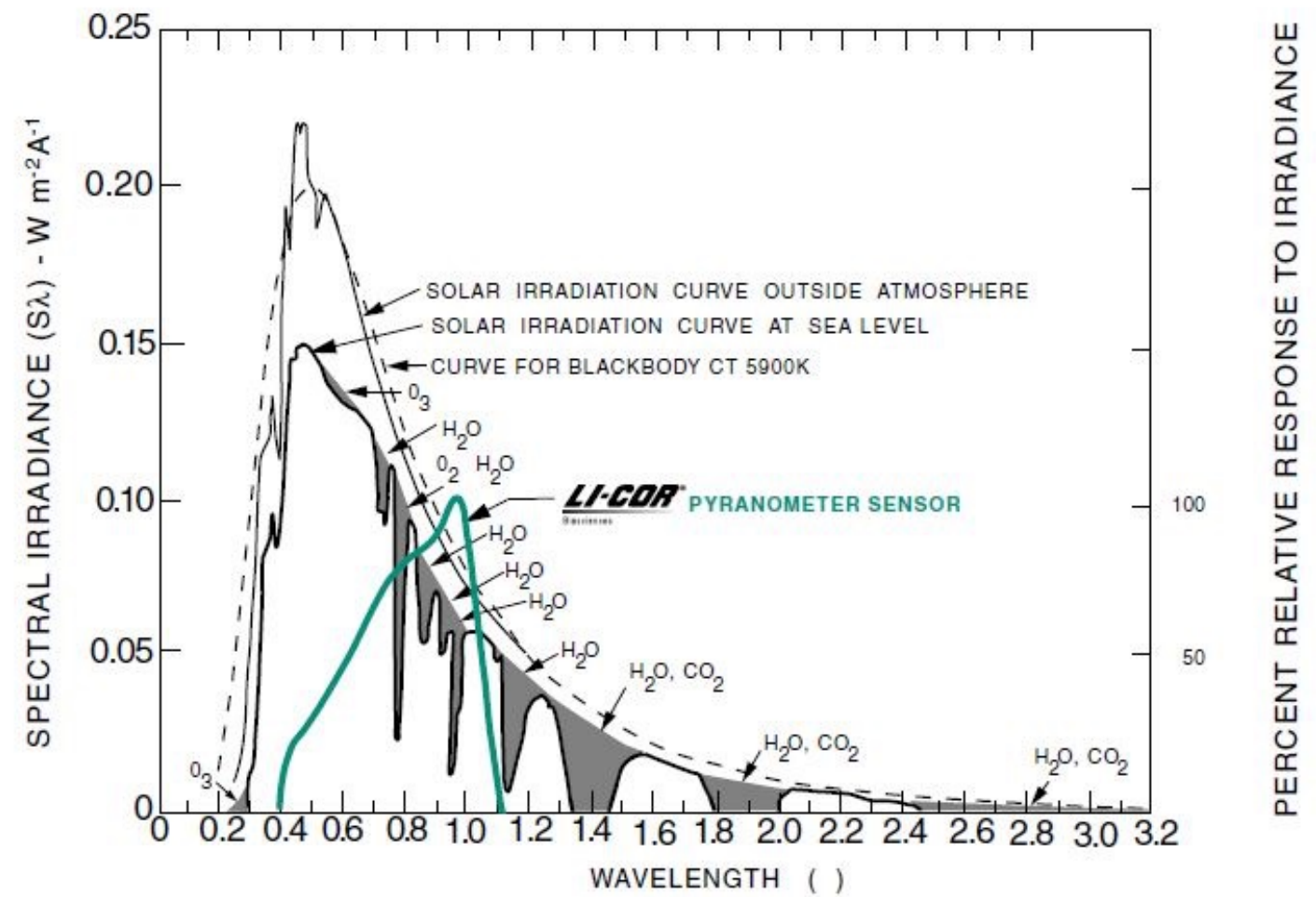
RSR2 developed in 2007

Led by 2008 specification and adoption by NREL SOLRMAP

Lowest cost component sum irradiance station ~\$15k

Accepted form of DHI for SCE





LI-COR Limitations

LI-COR

Si-Photodiode pyranometers underestimate diffuse
Si-photodiode calibration drift $\pm 2\%$ per year



Instrument (see Table A1 in Appendix A)	Sub-hourly Uncertainty % (range of bins to 80° Zenith)		Mean Daily Total Uncertainty %	
	Bias % max / min	Standard Deviation %	Monthly Bias % (monthly bins) max / min	Annual Bias ⁺ %
CM22_Vent	+0.6 to +0.4	2 to 3	+0.77 to +0.18	+0.48
RSR2_C (Glo)**	+1.0 to -1.2	4 to 6	+0.53 to -2.54	-0.73
RSR2_C (Dir)**	-3.5 to -7.5	16 to 19	-0.59 to -8.81	-6.60
RSR2_C (Dif)	-0.2 to +3.0	5 to 6	-1.06 to +3.03	+1.00
RSR2_U (Glo)**	-0.8 to -2.5	4 to 6	-0.81 to -3.59	-2.17
RSR2_U (Dir)**	+1.3 to +0.5	17 to 20	-2.07 to +3.37	+1.04
RSR2_U (Dif)**	-12.0 to -15.0	13 to 16	-19.3 to -19.6	-14.1

RSR2 Data Uncertainty: Wilcox et al., 2008





MBE Hourly Average RSR2 GHI: Habte et al., 2013

Clear

Max: 2.5 % Min: -1.0 %

Mostly Cloudy

Max: 4.69 % Min: -0.52 %





MBE Hourly Average RSR2 DNI: Habte et al., 2013

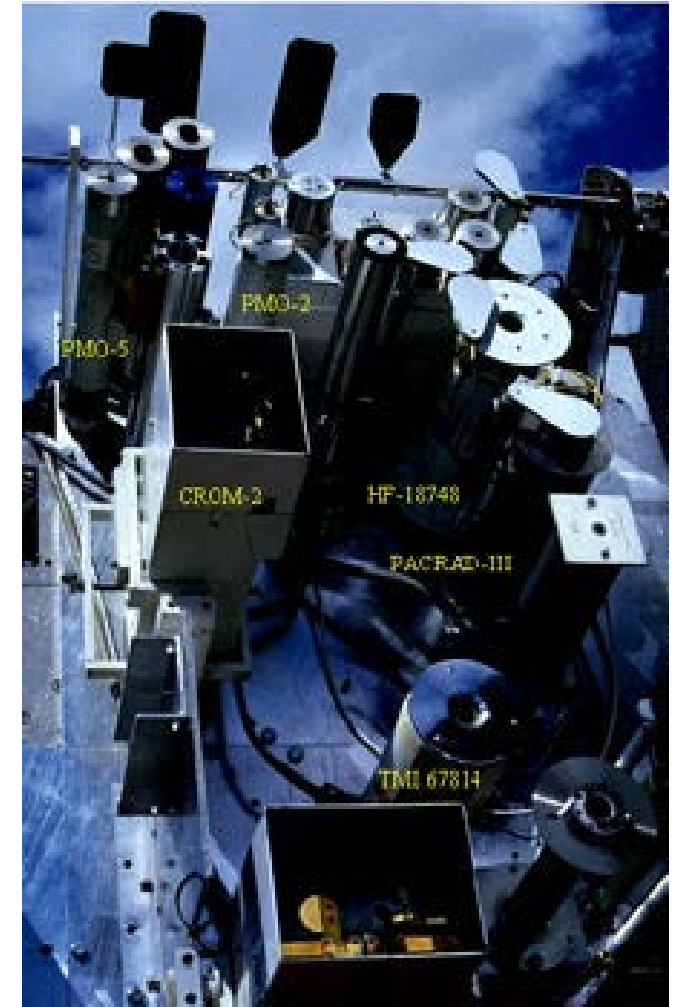
Clear

Max: 2.92 % Min: -0.52 %

Mostly Cloudy

Max: -23.68 % Min: -50.76 %





International Collaboration & Continued Research

MeteoSwiss/U of O/WRR(PMOD/WRC)

- Si-photodiode response to changing spectral distribution

- Temperature dependence

- Cosine response

NREL SRRL

- Long term characterization and further refinement





Areas of Further Improvement

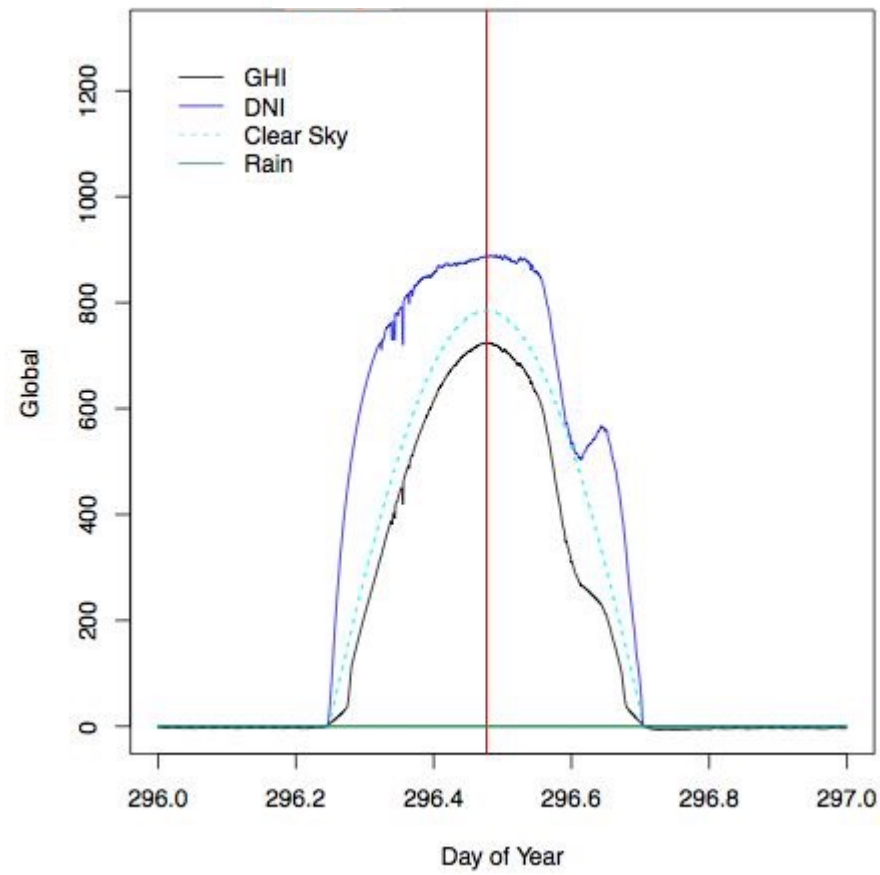
- Perform BORCAL calibrations of LI-CORs
- Evaluate and incorporate Precipitable Water Vapor (PWV)
- Develop fast response thermopile RSR
- Increase frequency of arm rotations
- Analyze shadowband across geographic and climatic regions
- Validate against high quality DNI stations



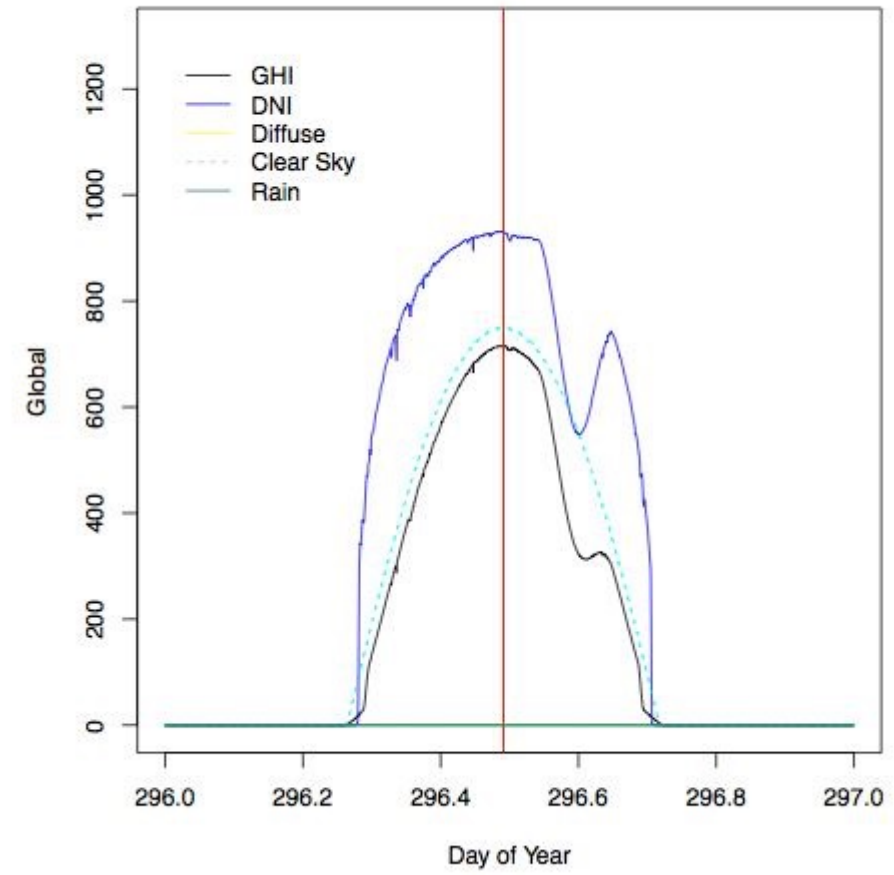


Courtesy Bob King

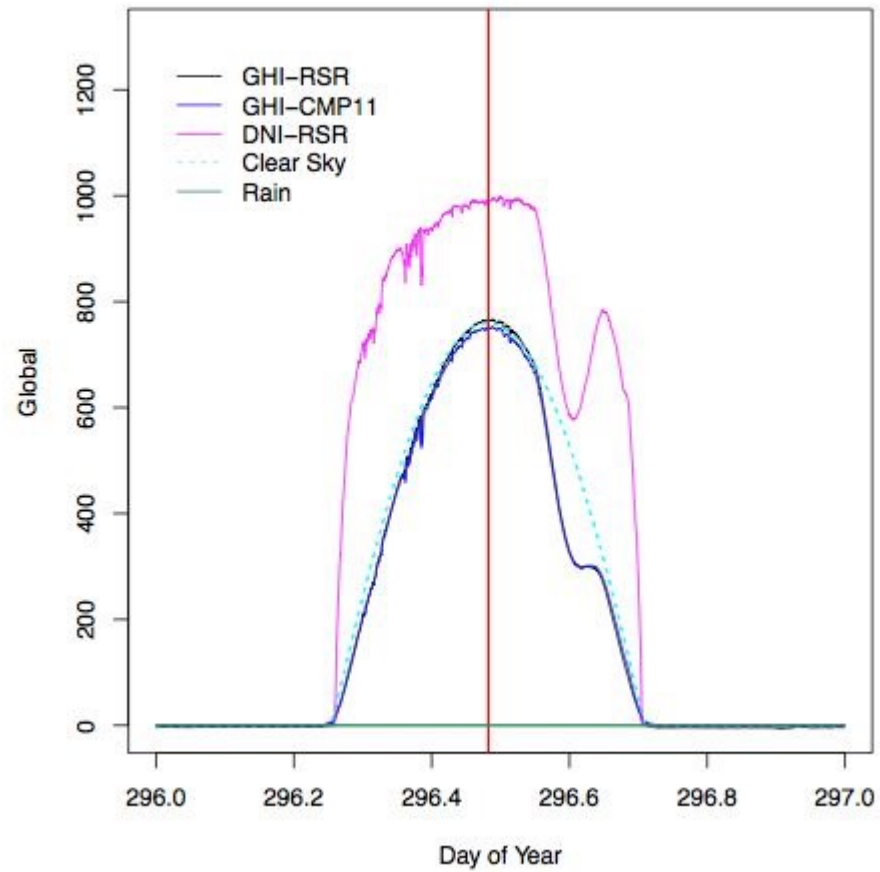
10/23/2014



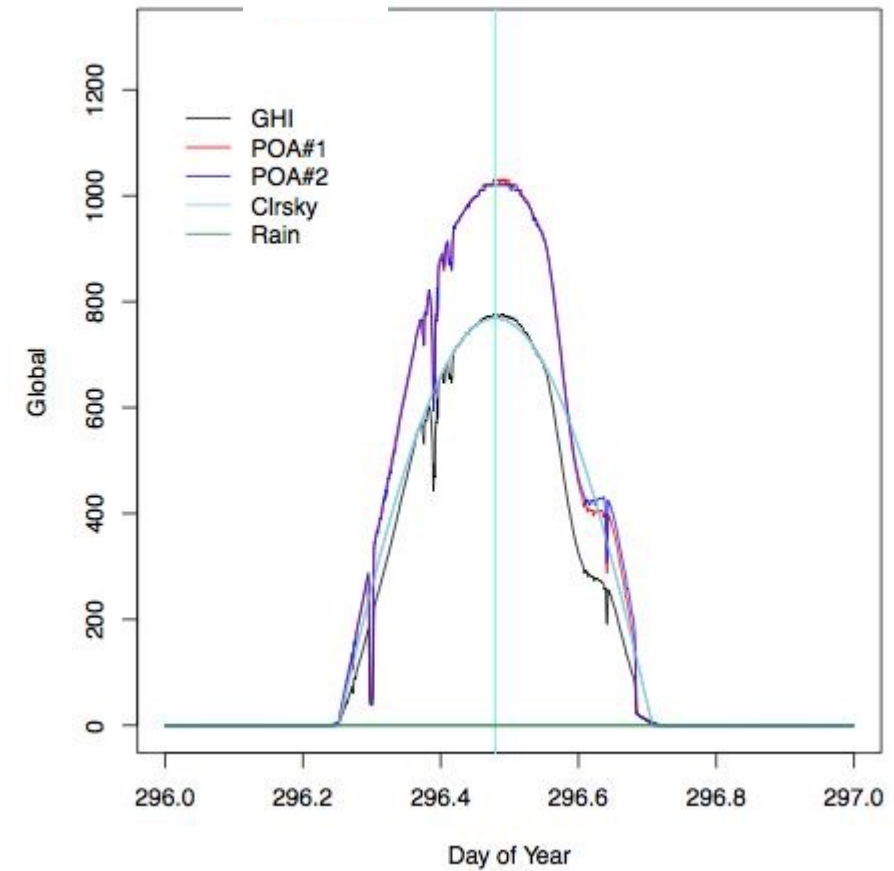
10/23/2014



10/23/2014



10/23/2014





Thanks!