

Photosynthetically Active Radiation From CERES SARB

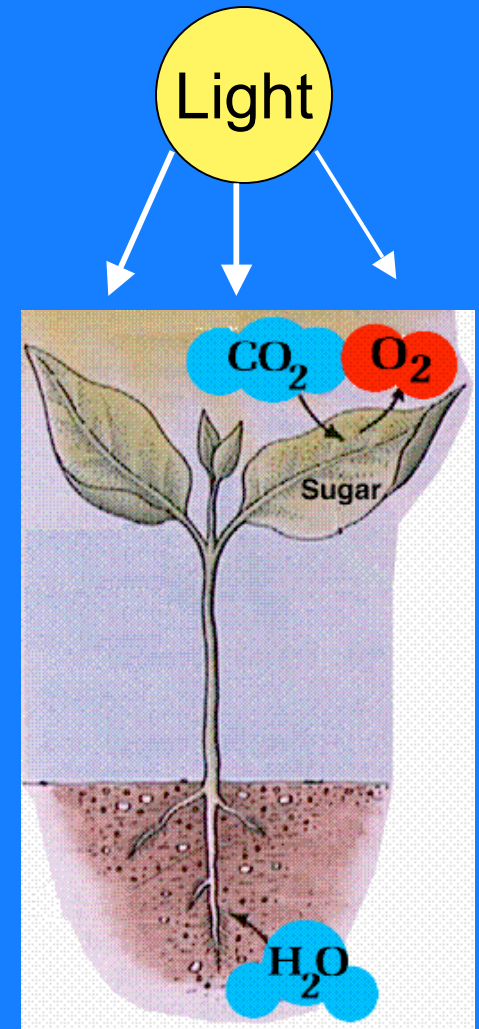
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05/04/2006

5th CERES-II STM

What is PAR?

- PAR is defined as the flux from the sun in the spectral range of 400-700 nm.
- It indicates the total energy available to plants for photosynthesis, and is thus a key parameter for biological and ecological studies.
- Needed for global Net Primary Production and Gross Primary Production modeling.

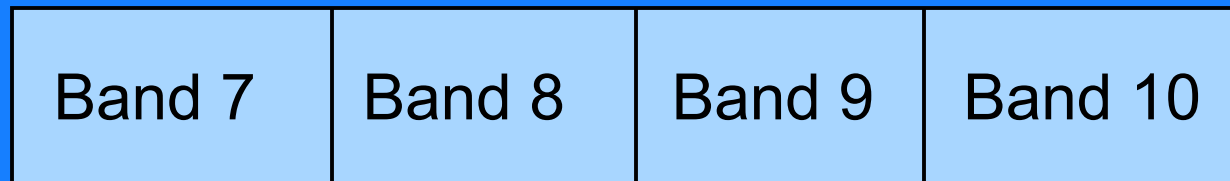


Retrieved PAR Products

- TOMS PAR (Eck and Dye, 1991);
- ISCCP PAR :
 - Potter et al. (1993)
 - Pinker and Laszlo (1992)
- SeaWiFS PAR (Frouin et al. 2003);
- CERES SARB PAR:
 - CRS Edition 2B
 - CRS Edition 3

PAR from CERES SARB

357nm 438 nm 498 nm 595 nm 692 nm



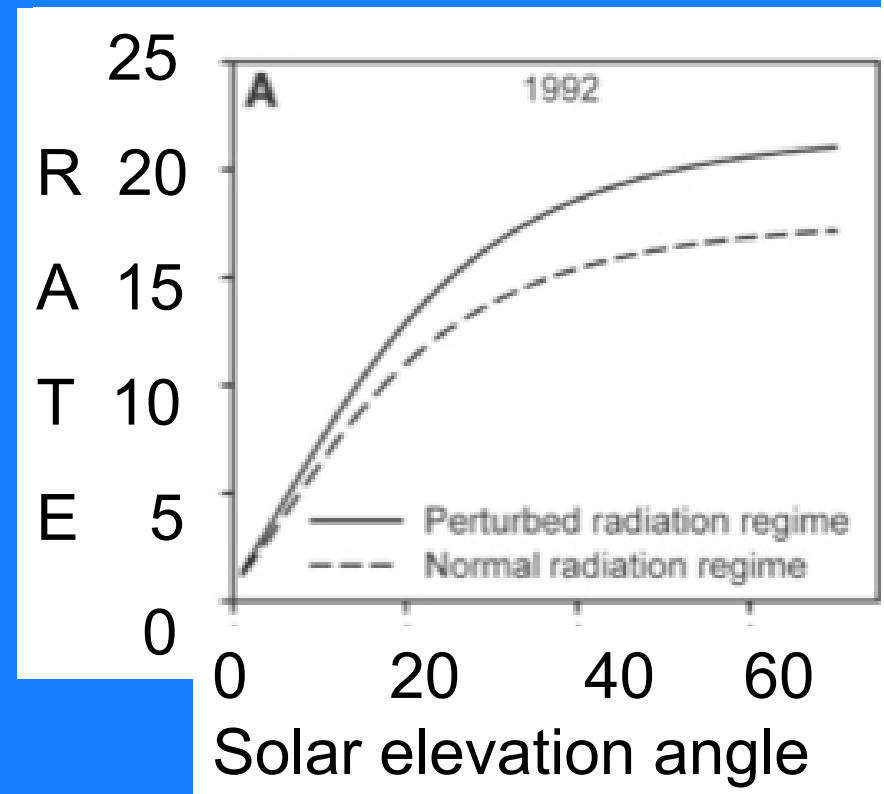
- To produce correct PAR, adjust band 7 and band 10
- $\gamma_7 = \text{Band 7} / \text{Band}(400 \sim 438)$
- $\gamma_{10} = \text{Band 10} / \text{Band}(595 \sim 700)$
- $\text{PAR} = \text{Band 7} / \gamma_7 + \text{Band 8} + \text{Band 9} + \text{Band 10} / \gamma_{10}$

Construct γ_7 and γ_{10} Look Up Table

- We construct look up table for γ_7 and γ_{10} taking into account all the parameters that they are sensitive to
 - Solar zenith angle
 - Aerosol optical depth
 - Cloud optical depth
 - Surface albedo
- The look up table is applied to Edition 3 and SYNI SARB

Ratio of direct to diffuse PAR

- Ecosystem can use diffuse light more efficiently
- Total PAR is important, so is the portion of diffuse PAR
- The rate of photosynthesis is increased by 23% and 8% following the 1991 Pinatubo (from Gu et al., 2003)
- CERES SARB provide



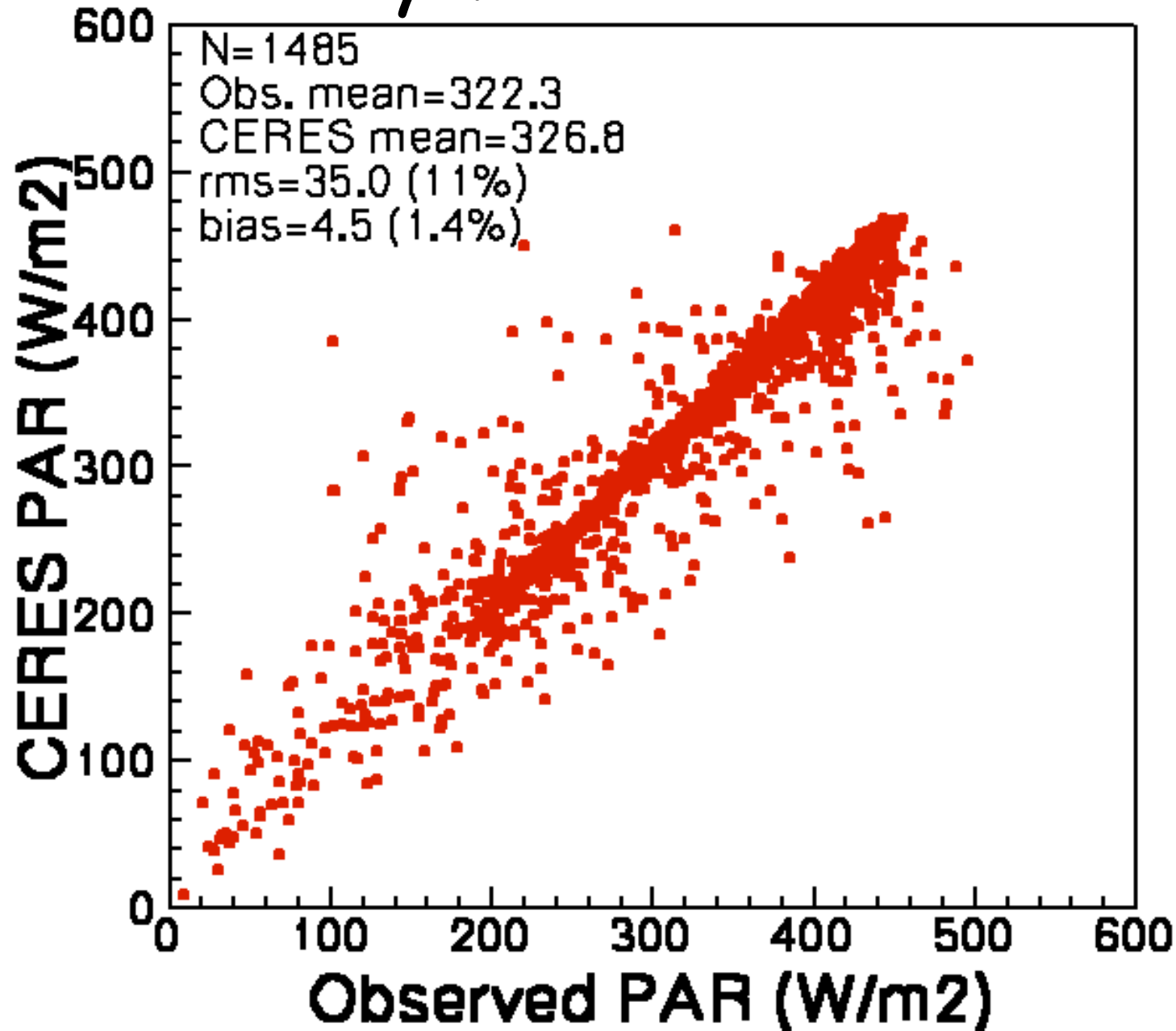
Ground measured PAR

- Prior to the mid 90s
 - Nearly none: TOMS use pyranometer for validation
- Now
 - SURFRAD sites: 7
 - USDA UV networks: 35
 - FLUXNET sites: over 300

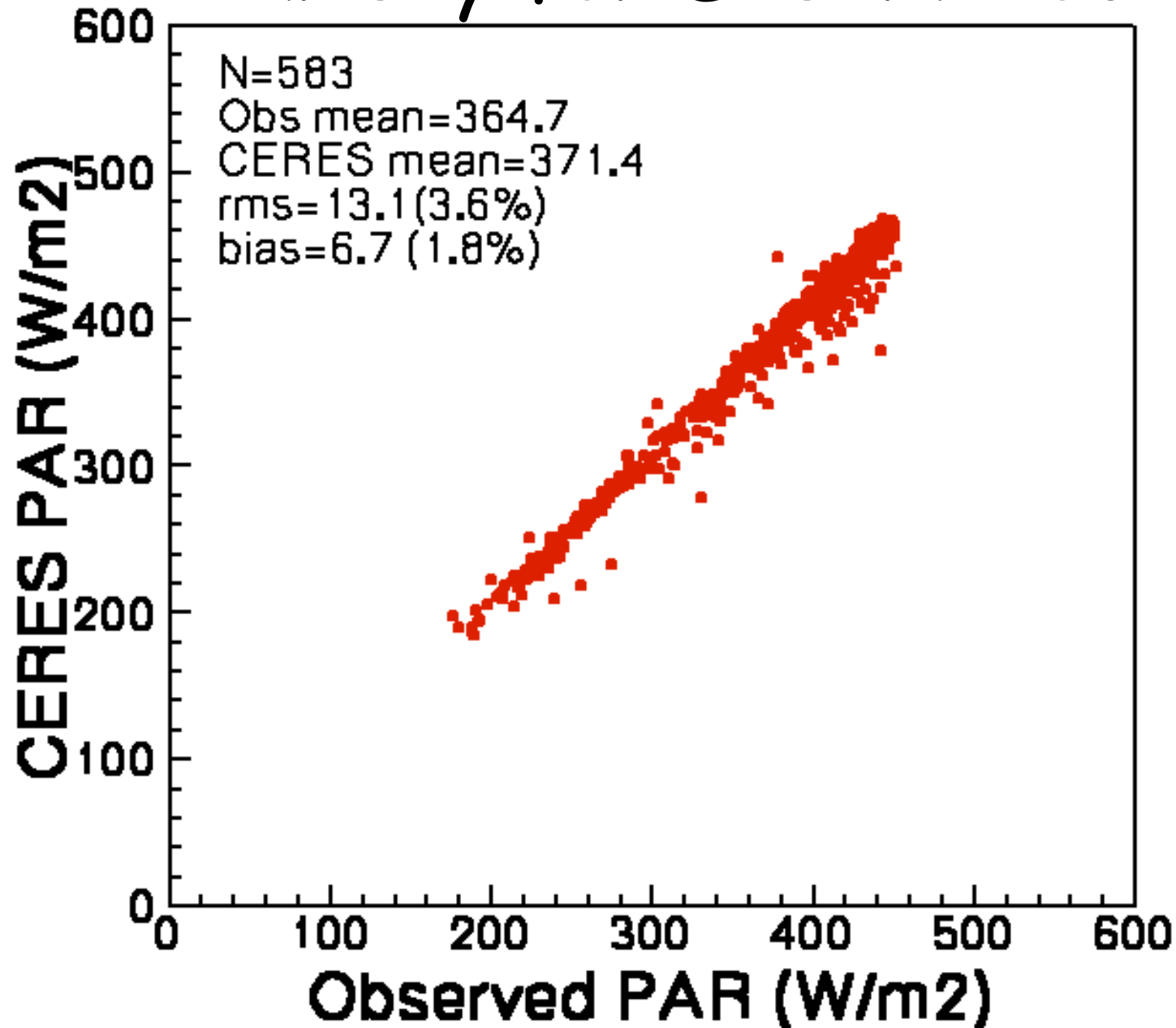
Validation for CERES PAR

- Grand Time Series runs Ed3 like algorithm which includes the look up table we discussed earlier
- Five years data of Terra over SURFRAD sites were used for validation

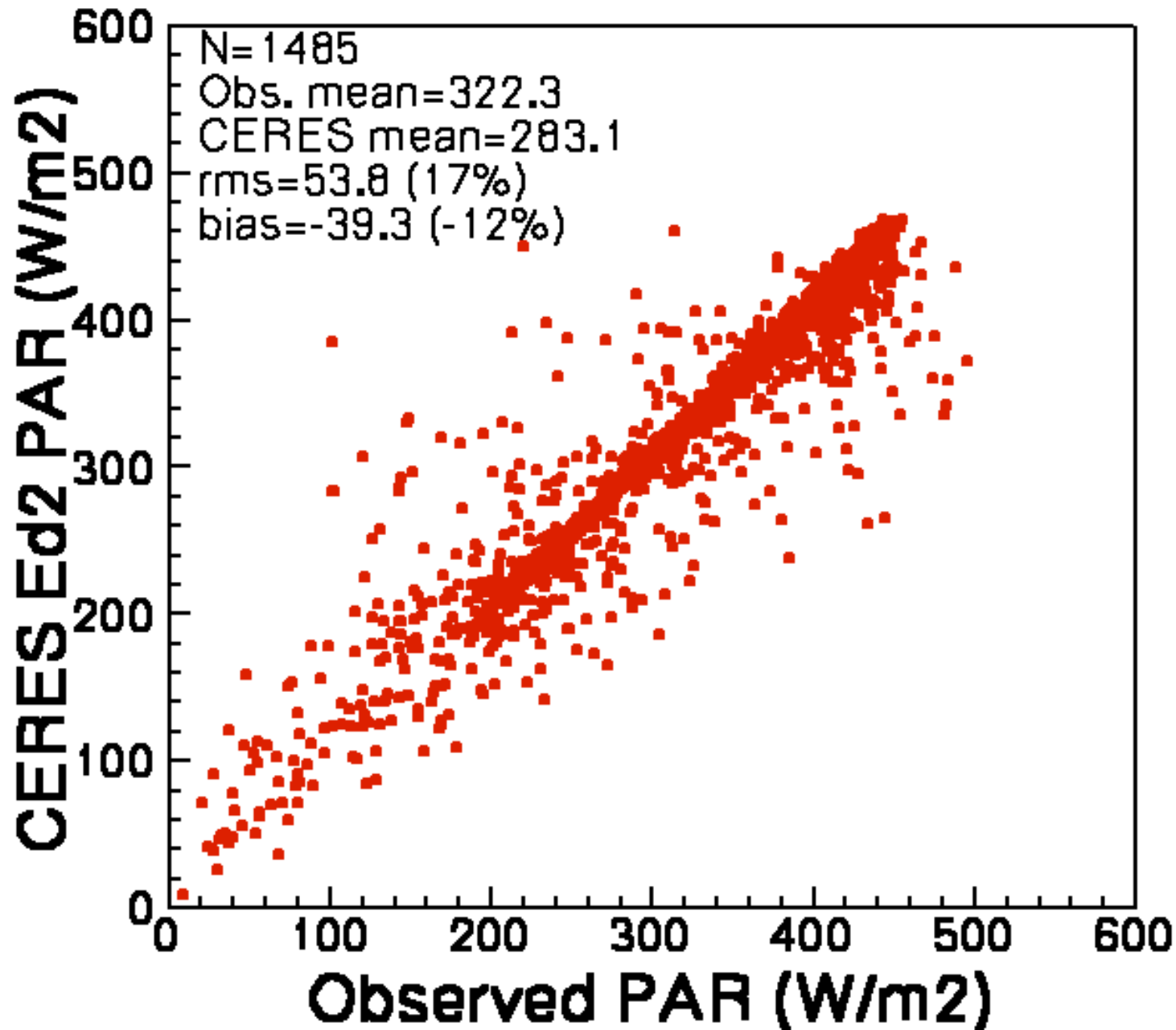
All sky for Desert Rock



Clear sky for Desert Rock



Ed2 PAR: Desert Rock



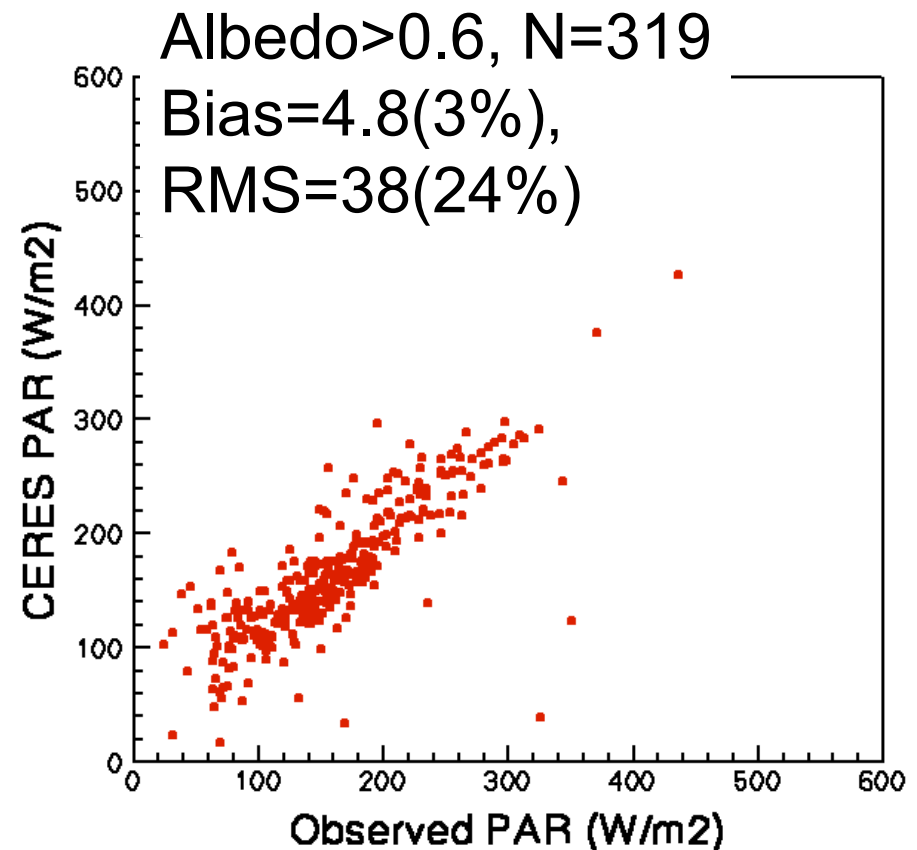
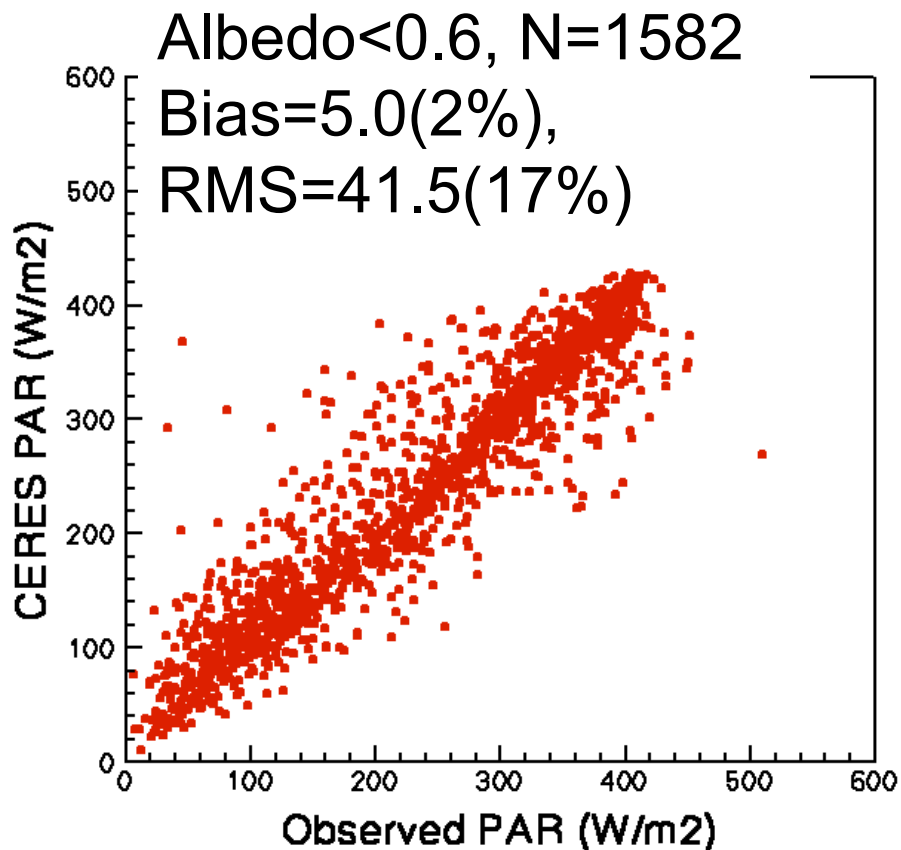
Some statistics

- For all sky, the largest relative bias is 9.3% at Bondville, and the smallest is 1.4% at Desert Rock
- For clear sky, the largest relative bias is 6.7% at Bondville, and the smallest is 0.1% at Fort Peck

	Bondville		Boulder		Desert Rock		Fort Peck		Goodwin Creek		Penn State		Sioux Falls	
	All	Clear	All	Clear	All	Clear	All	Clear	All	Clear	All	Clear	All	Clear
N	1076	371	1648	199	1485	583	1901	457	1497	300	1676	200	650	166
Mean Obs	223.7	292.4	267.2	299.7	322.3	364.7	224.2	272.2	244.9	304.9	204.6	299.6	232.2	293.5
Mean CERES	244.4	312.2	275.8	304.6	326.8	371.4	229.1	271.6	262.7	318.0	216.6	314.8	241.7	301.0
RMS	51.0	40.6	63.4	18.0	35.0	13.1	41.0	16.1	49.1	17.5	52.0	37.5	42.4	18.7
Bias	20.8	19.8	8.6	4.9	4.5	6.7	4.9	-0.5	17.8	13.1	12.1	15.2	9.4	7.6
Relative Bias	9.3	6.7	3.2	1.6	1.4	1.8	2.2	-0.1	7.2	4.3	5.9	5.1	4.0	2.6
P _{-10%~+10%}	45	72	53	97	80	98	55	87	53	97	40	80	54	92

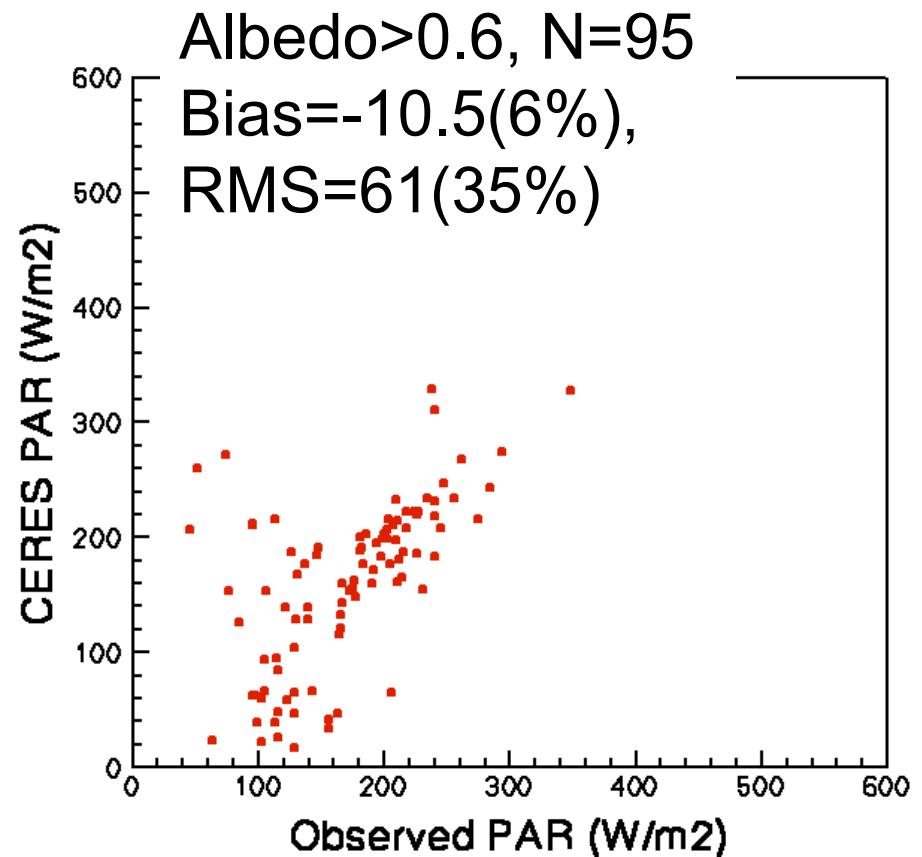
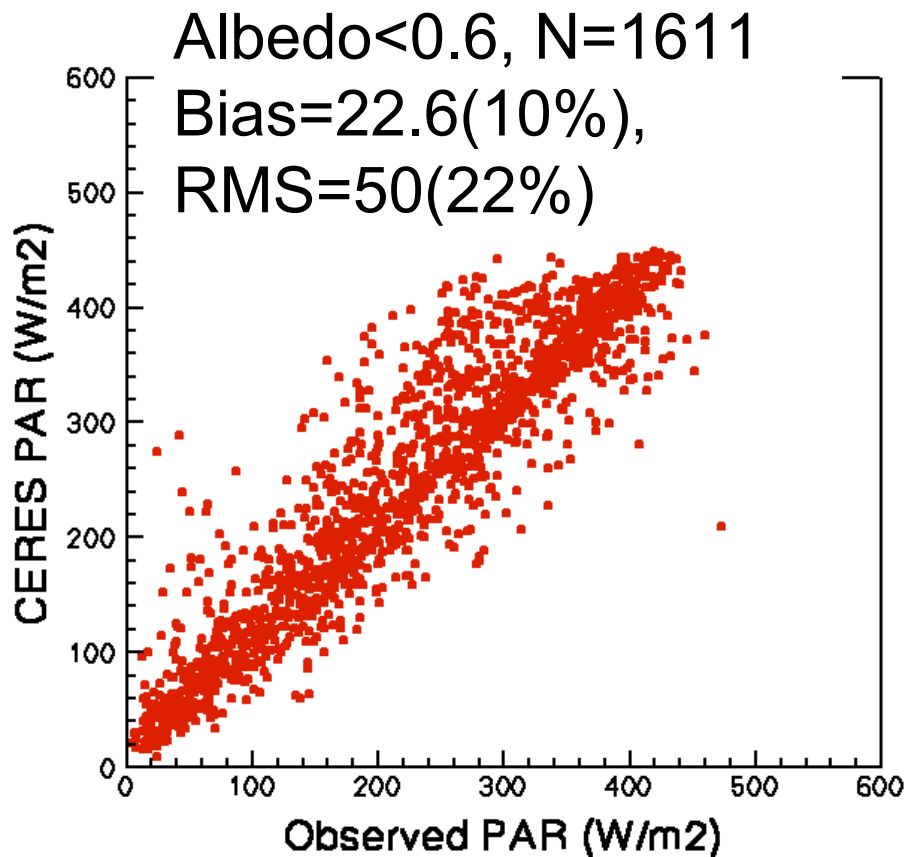
Low vs. high albedo surface

- Fort Peck



Low vs. high albedo surface

- Bondville



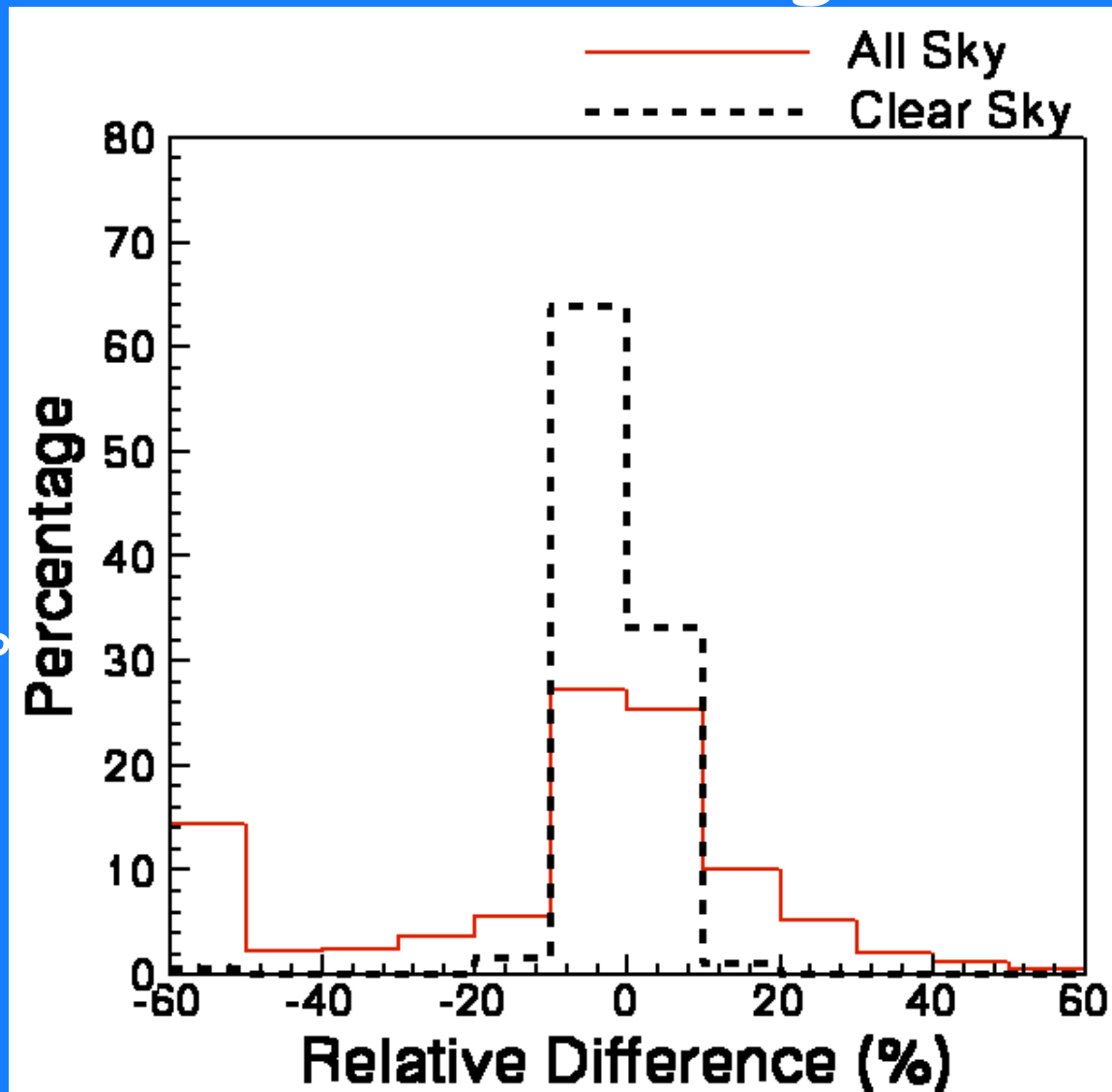
Accuracy of the measured PAR

- According to J. Augustine the uncertainty of Licor sensor is $\pm 10\%$;
- What is the percentage of our samples fall within this uncertainty?

Relative difference histogram

Boulder

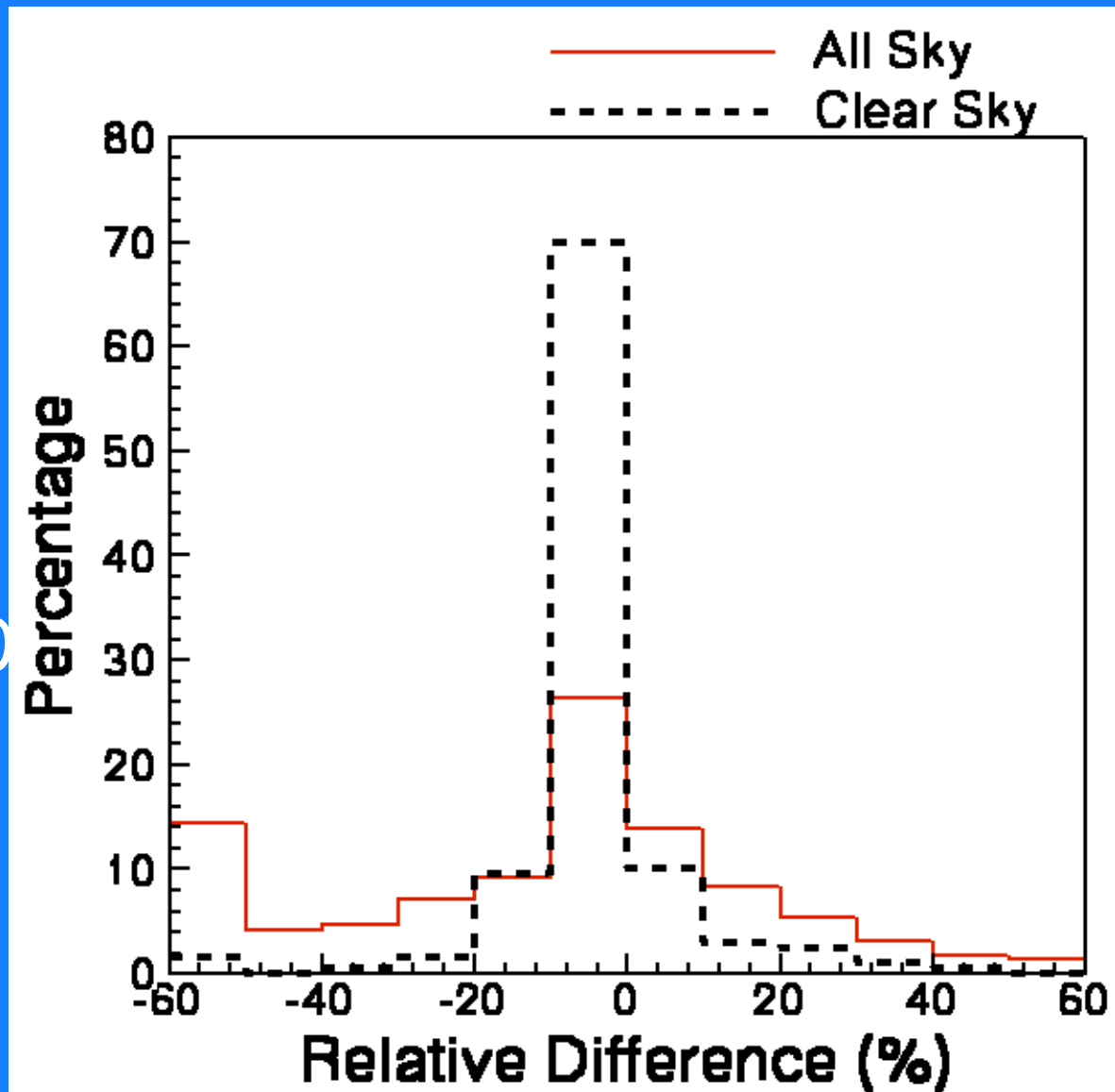
- All sky: 53% of sample with R_i within $\pm 10\%$
- Clear sky: 97% of sample with R_i within $\pm 10\%$



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Relative difference histogram

- Penn State
 - All sky: 40% of sample with R_i within $\pm 10\%$
 - Clear sky: 80% of sample with R_i within $\pm 10\%$

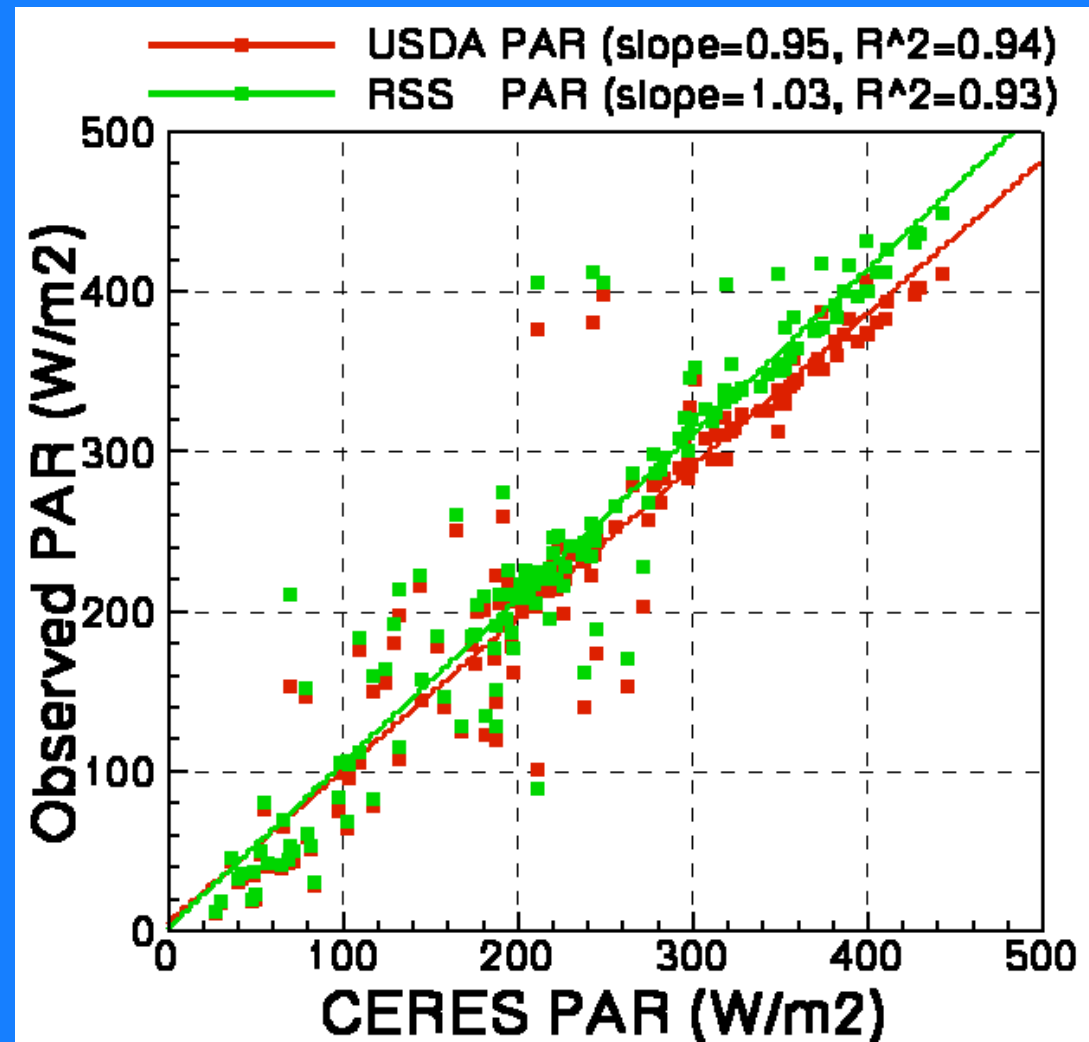


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CERES, RSS, and Licor PAR

- Data from Oct. 2003 to June 2004 (N=145)
- Licor vs CERES
 - Mean Licor: 227
 - Mean CERES: 232
 - RMS: 38 (16%)
- RSS vs CERES
 - Mean RSS: 242
 - Mean CERES: 232
 - RMS: 41 (18%)

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Paradox

- CERES PAR > Licor PAR
- CERES PAR < RSS integrated PAR
- 8th BSRN report presented some PAR sensor comparison: Licor sensor, in general, measured up to 15% more than other sensors (K&Z PAR Lite, Apogee)

Conclusions

- Look up tables were developed to produce accurate PAR from CERES SARB;
- PAR is validated using SURFRAD measured PAR. Relative bias ranges from 1.4% to 9.3% for all sky, and from -0.1% to 6.7% for clear sky;
- For high albedo surface, the algorithm underestimates the surface PAR at three out of four sites. But the absolute relative bias are comparable for both low and high albedo surface;

Conclusions (Con't)

- For more than 10,000 validation data points, 54% are within the PAR measurement uncertainty;
- For more than 2,200 clear sky validation data points, 89% are within the PAR measurement uncertainty;
- At SGP, CERES PAR agrees slightly better with Licor PAR than the RSS integrated PAR;

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- Accurate PAR sensor is needed!

Thanks!

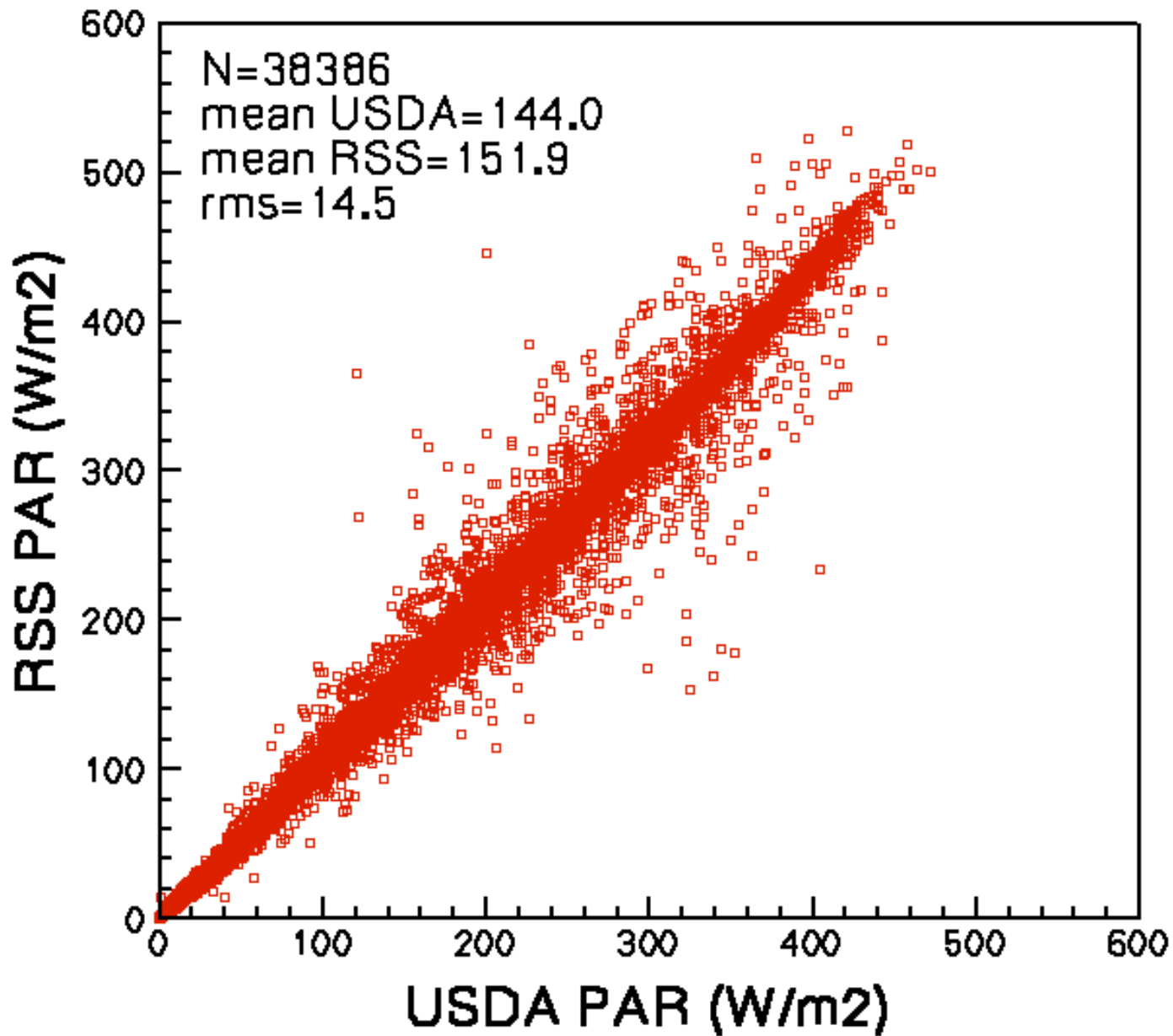
Accuracy of the measured PAR

- According to J. Augustine the uncertainty of Licor sensor is $\pm 10\%$;
- Define percentage of samples with relative difference between a% and b% as (R_i is the relative difference of the i^{th} sample):

$$P_{a\% \sim b\%} = \frac{1}{N} \sum_{i=1}^N \delta_i \times 100\%$$

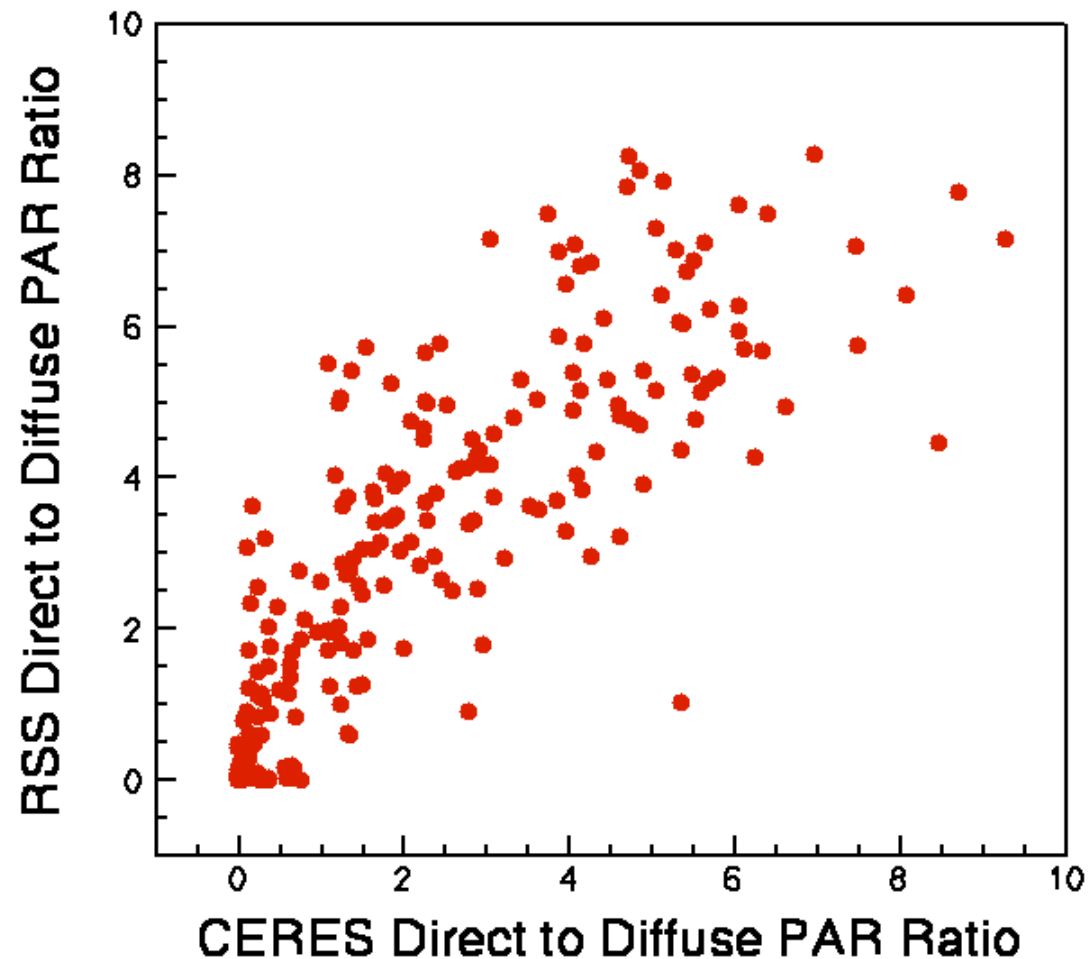
$$\begin{cases} \delta_i = 1 & a\% < R_i \leq b\% \\ \delta_i = 0 & \text{otherwise} \end{cases}$$

RSS vs Licor at SGP



RSS ratio vs CERES ratio

- N=271
- Mean RSS ratio: 2.59
- Mean CERES ratio: 1.93
- RMS: 1.40



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