

Ground-based Validation of Satellite Retrievals and Forecasts of Solar Irradiances

SURFRAD/ISIS & Moveable SURFRAD Unit

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- Definitions of GHI, DHI, DNI
- What are the SURFRAD and ISIS measurements?
- Why are irradiance measurements uncertain and what do we do about it?
- A word about satellite validation

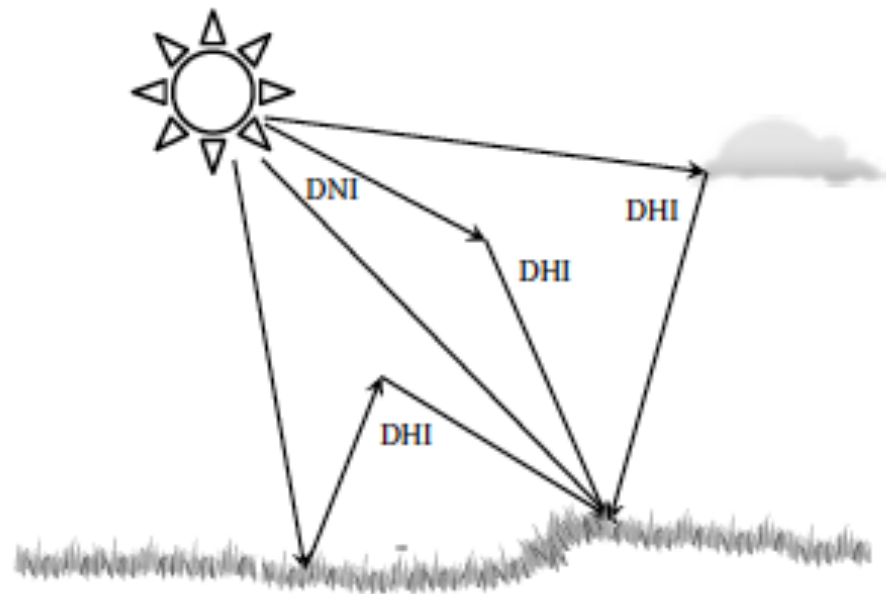


FIGURE 2.11 Components of solar radiation reaching the earth's surface. The extraterrestrial radiation is the sun's irradiance as it impinges on the top of the atmosphere of the earth. All of the radiation radiated from the sun is unscattered as it reaches the top of the earth's atmosphere in its orbit around the sun. As the sunlight passes through the atmosphere some of it is scattered and some is absorbed. The DNI measured at the surface is the portion of the sunlight that comes through the atmosphere with no scattering or absorption. Light scattered by the molecules, aerosols, and clouds that strikes the observation area is called diffuse horizontal irradiance (DHI). This also includes some irradiance that scattered from the earth's surface and then scattered again by clouds or the atmosphere to the observation site. In snow-covered areas, this rereflected radiation can be significant. The total irradiance on a horizontal surface, called GHI, is the sum of the DNI projected onto the horizontal surface plus all the diffuse radiation that makes it to the observing instrument.

From Vignola et al. 2012

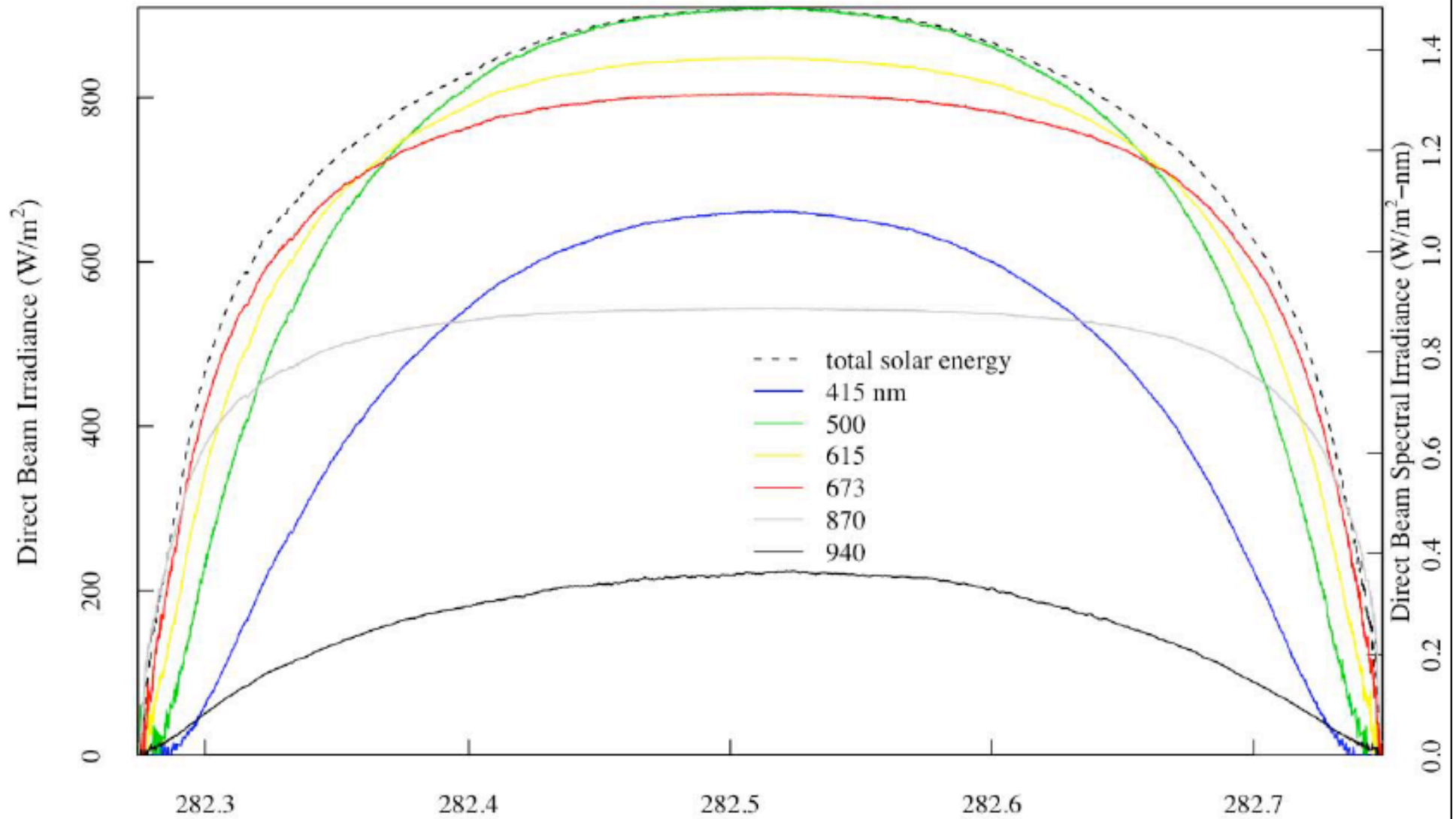
$$GHI = DNI * \cos(\text{solar zenith angle}) + DHI$$





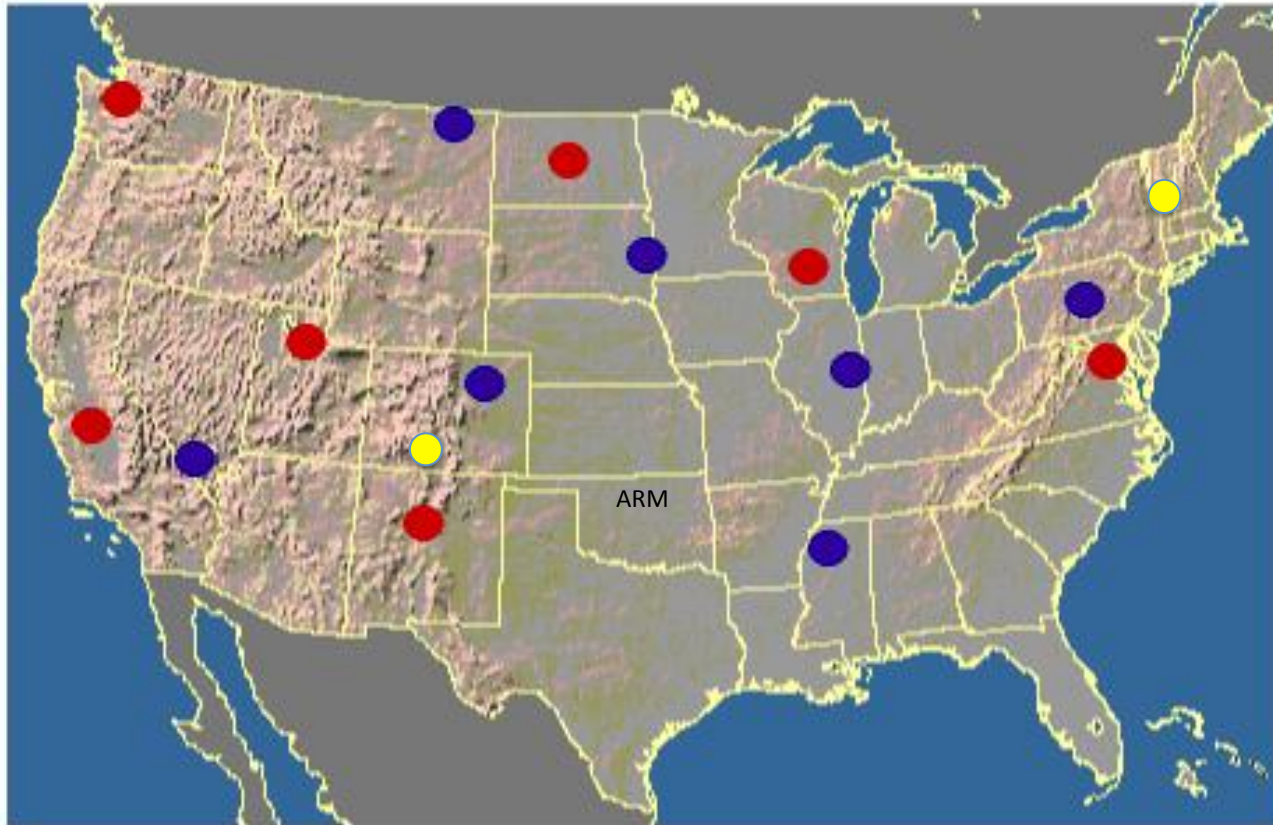


MFRSR-measured Solar Beam --Total Energy + Spectral @ Six Wavelengths



9 October 2008

The SURFRAD and ISIS Networks



- ISIS (Solar, UV)
- SURFRAD (Solar, IR, UV, PAR)
- Moveable SURFRAD



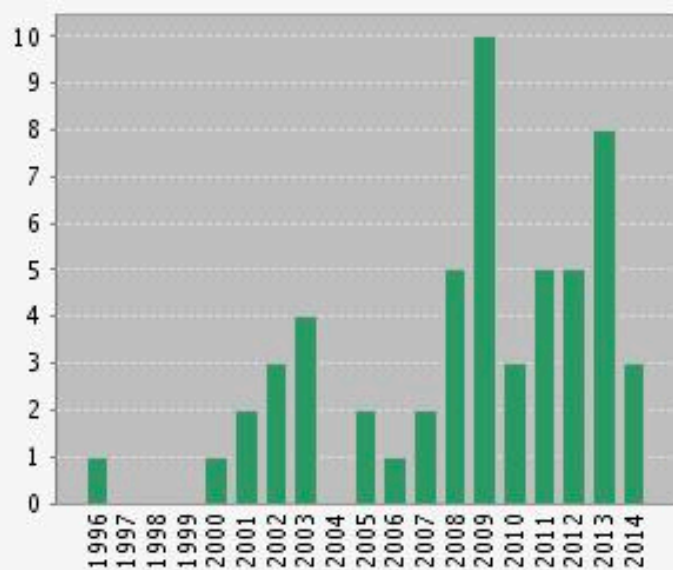
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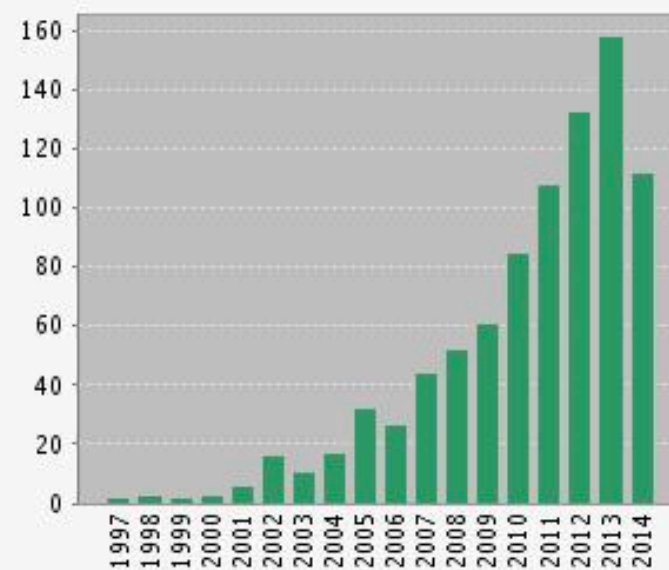
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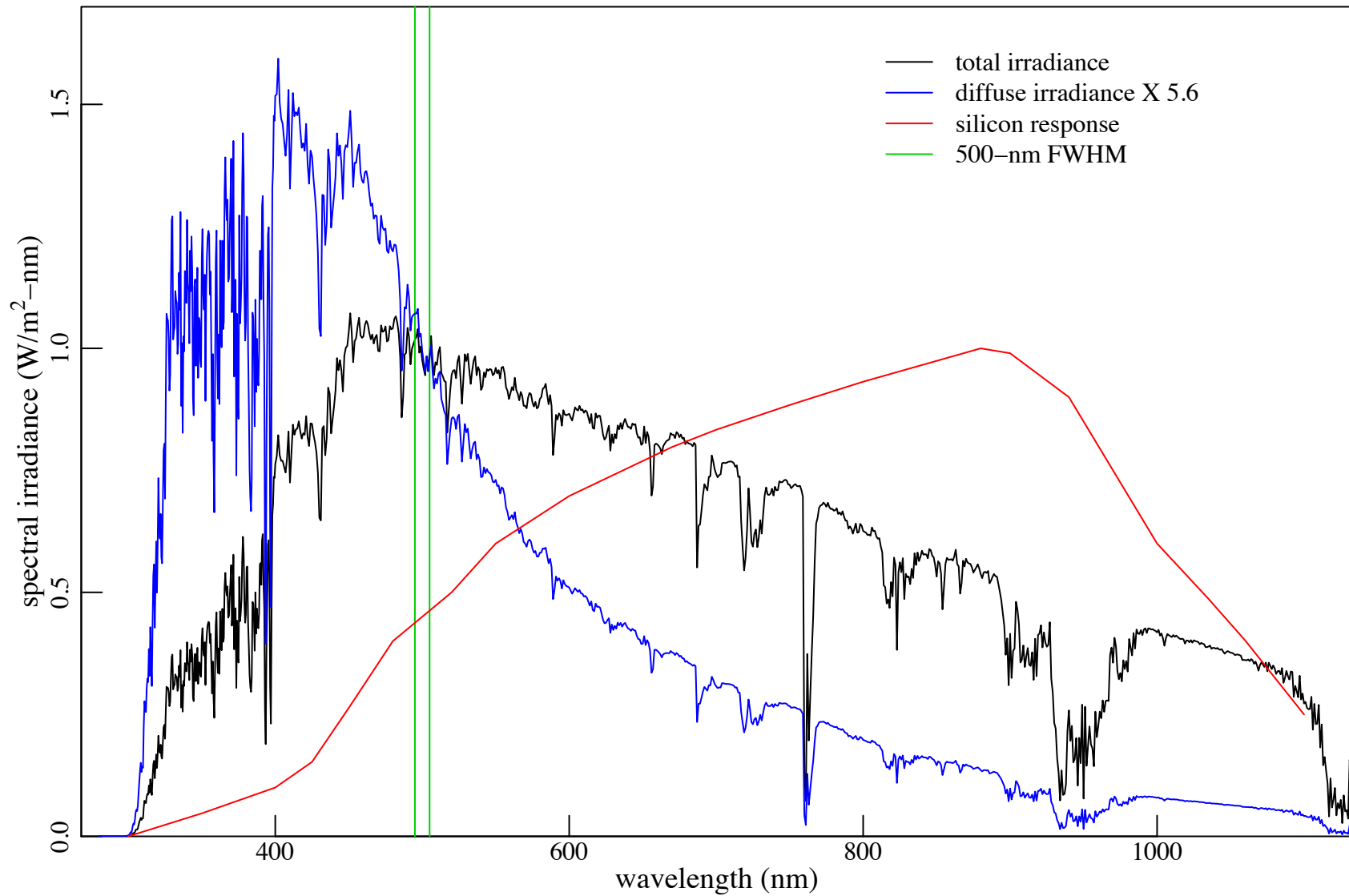
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Major Causes of Biases

- Spectral response (in silicon cell sensors)
- Cosine response (in all sensors; summation)
- Temperature response (mainly silicon)
- Offsets that remain uncorrected
- Aperture obstructions: ice, water, dirt, bird deposits (may overwhelm anything else)

Thermopile Response



Definitions

- Global (total) irradiance on horizontal surface
- Direct (beam) irradiance normal to the sun
- Diffuse irradiance on horizontal surface

Lambert's Cosine Law

The irradiance or illuminance falling on any surface varies as the cosine of the incident angle, θ . The perceived measurement area orthogonal to the incident flux is reduced at oblique angles, causing light to spread out over a wider area than it would if perpendicular to the measurement plane.

Cosine Law: $E_{\theta} = E \cdot \cos(\theta)$

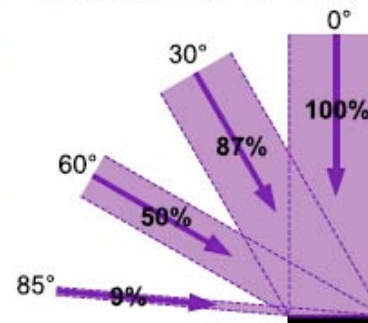


Fig. 6.3 Lambert's cosine law.

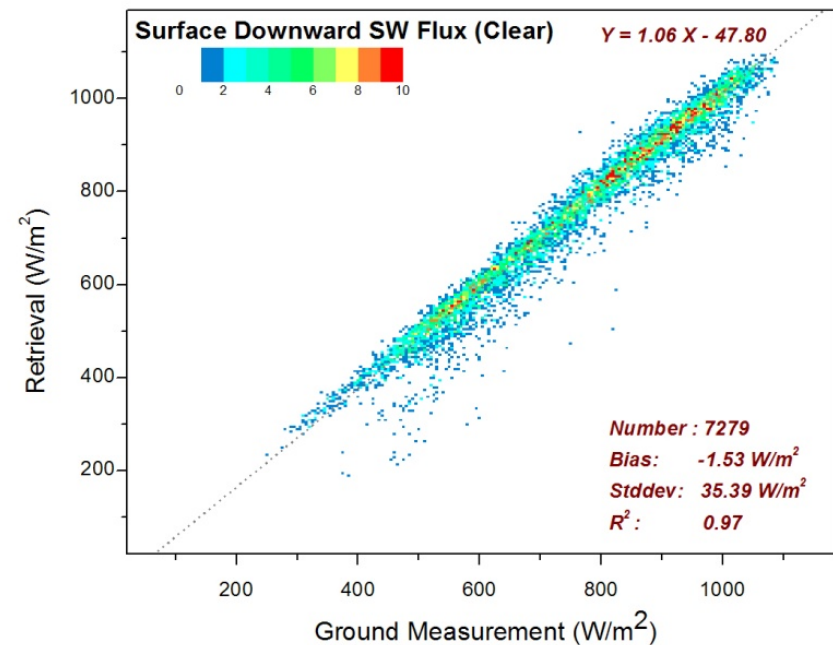
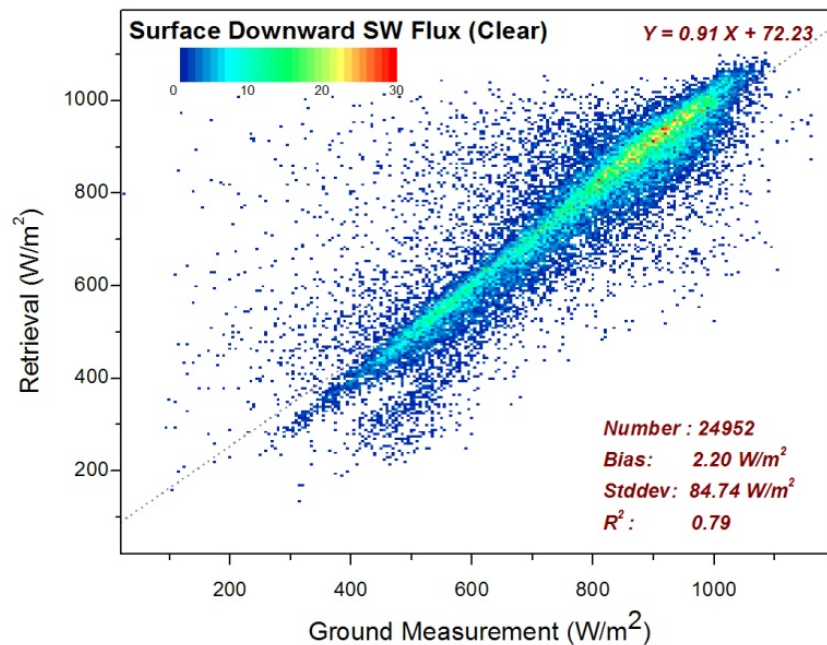
From Alex Ryer's "The Light Measurement Handbook" from Int'l Light

- Global = direct * cos(solar zenith angle) + diffuse

	Best Current Uncertainty – Windowed Cavity (95%)	Thermopile (95%) Operational	Silicon Cell (95%) Operational
Direct Normal Irradiance (DNI)	±0.5%	±0.70%	±3.23%
Diffuse Horizontal Irradiance (DNI)	NA	±2.2%+0.2Wm ⁻²	±10% (estimate)
Global Horizontal Irradiance (GHI) Component Sum	NA	±2.0%	±6.6%
Plane of Array Irradiance	NA	±3.0%	> ±6.6% (reflectivity)

VALIDATION – CLEAR SKY

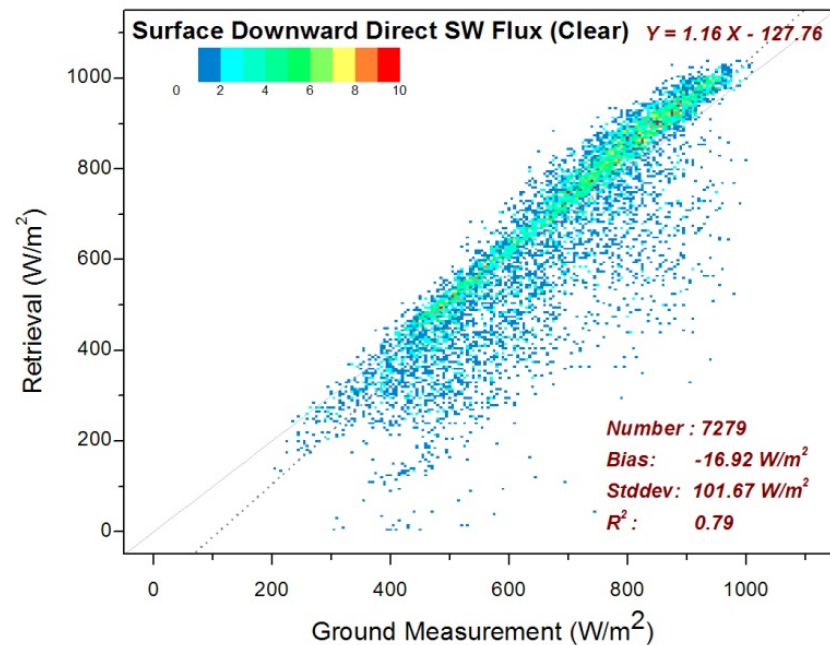
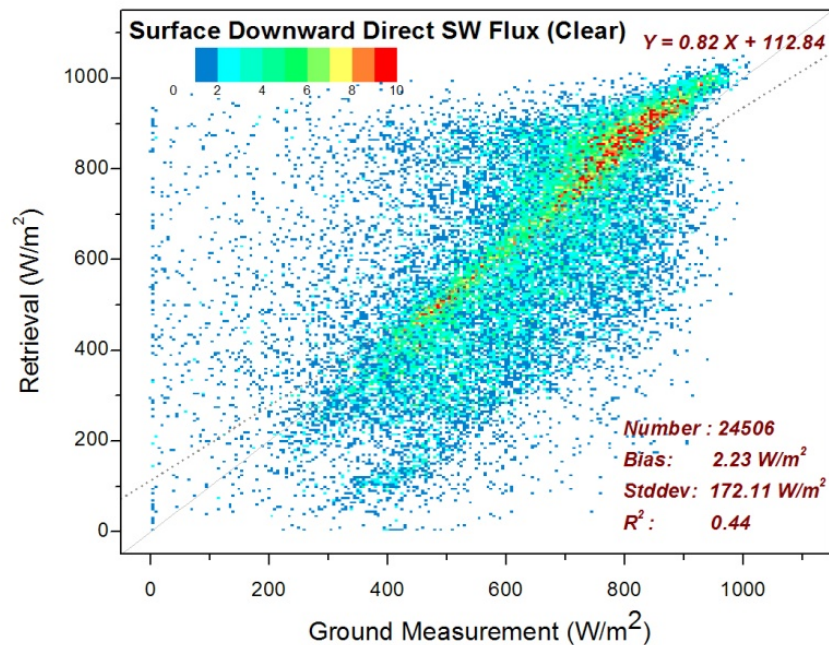
- Validation of **GHI** against ground measurement:
 - Left: 100% clear sky is identified by satellite
 - Right: both satellite and ground report 100% clear sky



Credit: Istvan Laszlo

VALIDATION – CLEAR SKY

- Validation of **DIR** against ground measurement:
 - Left: 100% clear sky is identified by satellite
 - Right: both satellite and ground report 100% clear sky

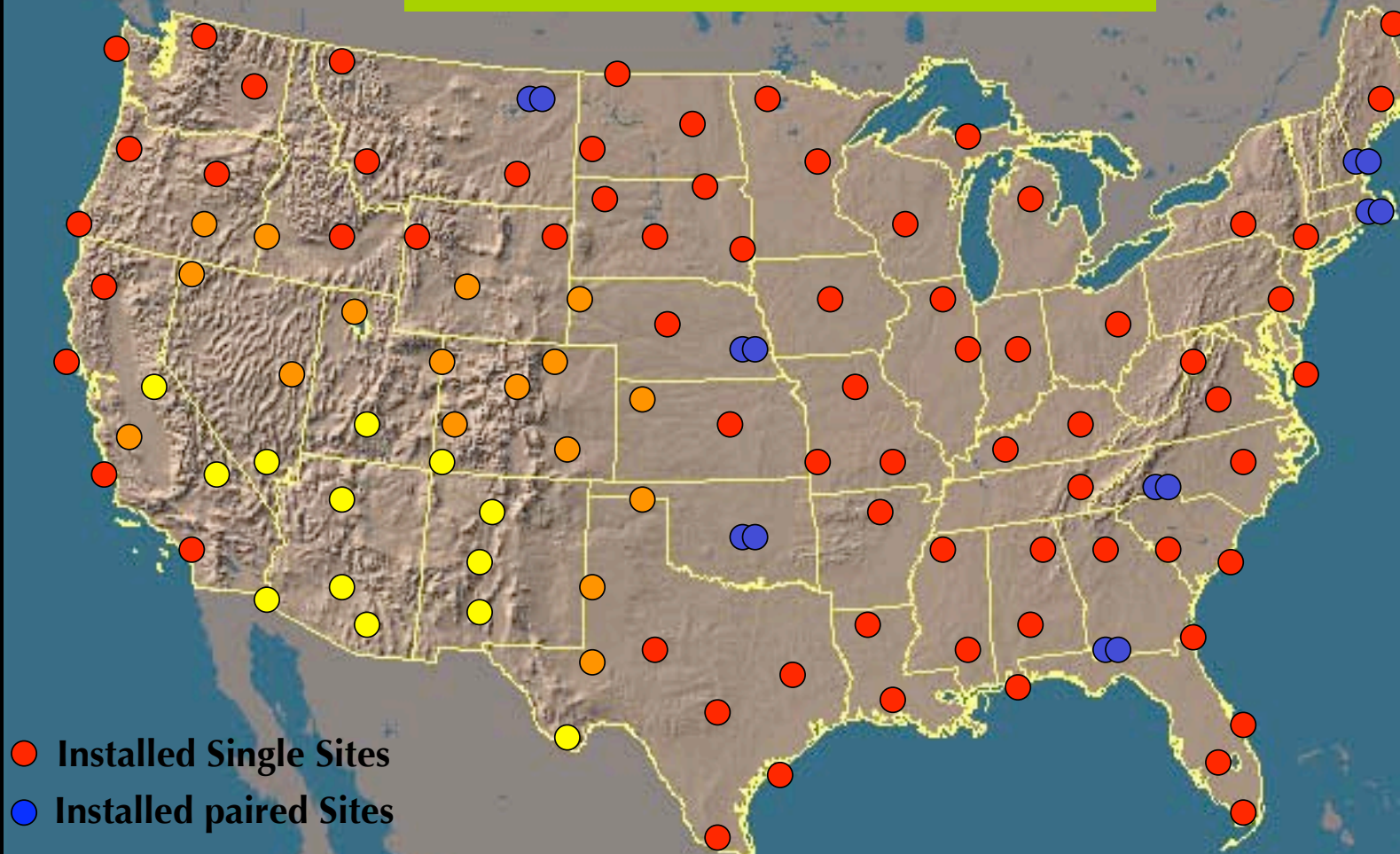


Credit: Istvan Laszlo

The End

CONUS US-CRN Stations

Sites with High Solar Energy Potential
(in yellow ● and orange ●)



- Installed Single Sites
- Installed paired Sites

Courtesy: ATDD/Air Resources Laboratory