Weather Effects on Solar Power Production

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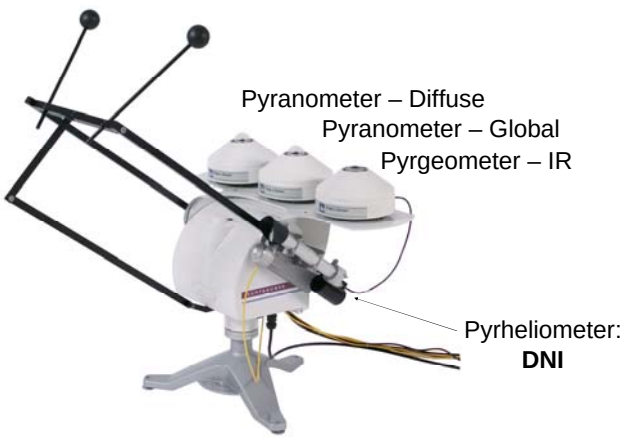
More than 50% of solar radiation interacts with the atmosphere before reaching the surface

Our group (in collaboration with others) is developing the technology needed to quantify and provide predictions of the role of the atmosphere in regulating the production capacity of various established and frontier solar technologies.

- Clouds, aerosol, and water vapor are highly variant in the atmosphere. They each significantly reduce surface solar insolation, and alter its spectrum and angular distribution. These influences interact with the unique spectral and angular configurations of the various solar technology. They also contribute to the largest errors in satellite-based climatologies.
- We investigate how wind and ambient temperatures regulate the performance characteristics and present hazards to solar installations.
- We are measuring surface radiation, meteorological data, and the output of PV panels at the TEP test yard to develop and refine models of various classes of solar power technologies, and their responses to weather.
- A key goal is to develop the capability to provide 1km-scale climatology in S. Arizona and refine weather forecast models to provide forecasts of technology-specific power production on a spectrum of timescales ranging from minutes to seasons.

UA Solar Resource Observatory

The Department of Atmospheric Sciences currently operates an ISO First Class pyrheliometer (DNI) and pyranometer (purchased with AZRISE funds) to monitor the solar resource (0.3 μm – 4.0 μm) on the roof of PAS with NIST traceable calibrations

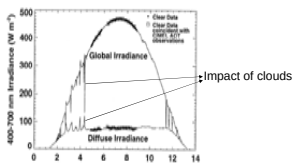


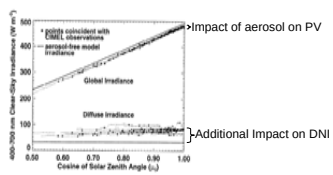
In part due to our involvement w/ AZRISE, we have received and responded to a targeted RFP by NREL to establish a Solar Resource Observatory at the UA following Baseline Surface Radiation Network (BSRN) calibration standards (A subset of the proposed system is included in the image above).

Insolation Climatology and Forecasting

Effects of aerosol:

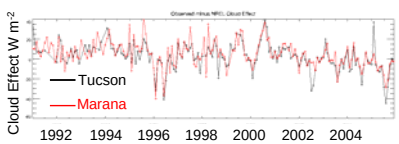
- Reduces DNI by 5-10% in silicon spectrum (S. AZ)
- 80% of the reduction comes back as diffuse radiation, which is available to PV panels





Effects of clouds:

- Reduces DNI strongly and on rapid timescales
- Amount of scattered radiation available to PV depends on cloud thickness and type.



Retrieval from satellites

- Based on scattering signal
- Must separate effects of clouds and aerosols from surface reflection
- Large uncertainties are improved w/ surface observations of aerosol, insolation, and clouds
- Anomalies in NREL data to be reconciled w/ calibrated data

TEP Solar Test Yard

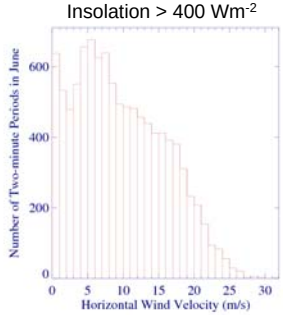
The University of Arizona collaborates with Tucson Electric Power to acquire data from the TEP Solar Test Yard. These data will be used to validate models we are developing of the thermal and radiometric responses of the various commercially available technologies at this site.

(***See poster by Cronin et al. describing the Test Yard***)

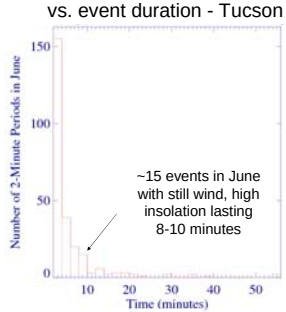
Putting Weather into Thermal Models of Solar Technologies

A primary factor controlling the lifetime of photovoltaic modules in large dish-concentrators is the thermal stressing that occurs during periods of high insolation and low wind. A climatology of conditions characterized by high insolation and low wind has been developed to facilitate thermal modeling of large dish concentrators

Histogram of wind speed when Insolation > 400 Wm^{-2}



Frequency of < 1 kt. wind events vs. event duration - Tucson



Wind also regulates the temperature of PV arrays. Since the efficiency of silicon decreases with temperature, wind can play an important role in PV efficiency. We plan to use the test-yard data to validate simple thermal and optical models of PV panels incorporating observed wind, insolation, and ambient temperature data.