Albedo Data Sets for Bifacial PV Systems

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Introduction

• Albedo is important for estimating economic and performance benefits of bifacial PV systems
• In 2019, DOE funded NREL to establish a database of measured albedo data for various surfaces and locations
• Database includes existing measurement network data and data contributed by the PV industry
Albedo

• Albedo of a surface is the fraction of the incident sunlight that the surface reflects
• Not a constant for a surface
• Varies with spectral and angular distribution of light
  – Cloudy versus sunny
  – Sun position (time of day, season, latitude)
• Dry versus wet
• Roughness

Albedo = Reflected ÷ Incident
Albedo Measurement

- Two pyranometers mounted horizontally, with one inverted to measure the ground-reflected irradiance (GRI)
- Mounting height is 1-2 meters for smooth surfaces
- Increased height for snow conditions, unchecked vegetation, and croplands
Database Elements

• Global horizontal Irradiance (GHI) and ground-reflected irradiance (GRI) for albedo.
• If available - direct normal irradiance, diffuse horizontal irradiance, dry bulb temperature, relative humidity, wind speed, wind direction, atmospheric pressure, and precipitation.
• Quality assessment flags assigned to data to indicate if within reasonable limits.
Albedo Data

- Time-series data at (1) the original temporal resolution (from 30 seconds to 30 minutes) and (2) reformatted to hourly data
- Albedo statistics – monthly and yearly means, medians, minimums, maximums, and standard deviations
- User’s Guide – Describes available data sets, site information, and provides graphs of seasonal and diurnal variations
- Data products are available from: [https://datahub.duramat.org/project/about/albedo-study](https://datahub.duramat.org/project/about/albedo-study)
SURFRAD Network

Surface Radiation budget (SURFRAD) network

- Operated by National Oceanic and Atmospheric Administration (NOAA)
- High quality measurements to support climate research, weather forecasting, satellite and education communities
- 7 stations, 15 to 24 years of data
AmeriFlux Network

- Network managed by the Lawrence Berkeley National Laboratory
- Stations managed by individual scientists in North, Central, and South America
- Purpose is measuring ecosystem CO2, water, and energy fluxes
- We used a subset of 28 stations (grasslands, deserts, low brush or crops)
- From 1 to 15 years of data, information on equipment and maintenance varies by station
PV Industry Contributions

• Canadian Solar, Inc (contributed by Jean-Nicolas Jaubert and Baohua He)
  – Concrete surface albedo in Changshu, Jiangsu, China
  – Desert sand-wheatgrass surface albedo near Wuhai, Inner Mongolia, China
• SunPower Corp (contributed by Ben Bourne, Fabrizio Farina, and Adam Hoffman)
  – Gray gravel surface albedo in Davis, CA
### Interannual Variability

#### SURFRAD Network Annual Albedo Statistics

<table>
<thead>
<tr>
<th>Location</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bondville, IL</td>
<td>0.247</td>
<td>0.015</td>
</tr>
<tr>
<td>Boulder, CO</td>
<td>0.199</td>
<td>0.011</td>
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<tr>
<td>Desert Rock, NV</td>
<td>0.211</td>
<td>0.004</td>
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<tr>
<td>Fort Peck, MT</td>
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<tr>
<td>Goodwin Creek, MS</td>
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<td>0.006</td>
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<tr>
<td>Penn State Univ, PA</td>
<td>0.252</td>
<td>0.019</td>
</tr>
<tr>
<td>Sioux Falls, SD</td>
<td>0.238</td>
<td>0.025</td>
</tr>
</tbody>
</table>
Summary

- Database of measured albedo values compiled
  - Time series data, hourly and sub-hourly
  - Monthly and annual means and statistics
- Data and a user’s guide describing the data are available for download from NREL’s DuraMAT website at https://datahub.duramat.org/project/about/albedo-study.
- More albedo data will be added when available
Thank you

www.nrel.gov

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