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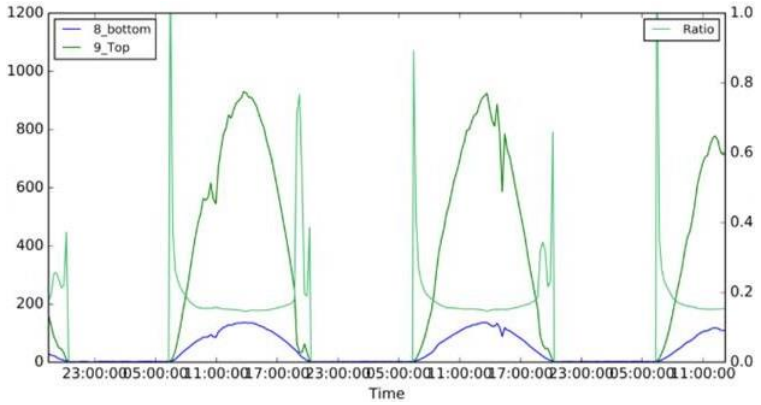
# Ground Albedo Field Measurements

## *NREL Bifacial PV Workshop 2018*

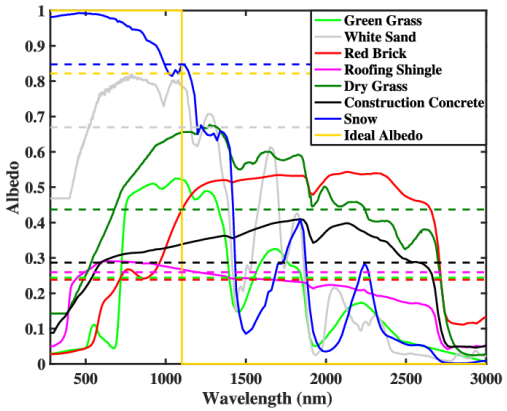
Ben Bourne | September 11, 2018

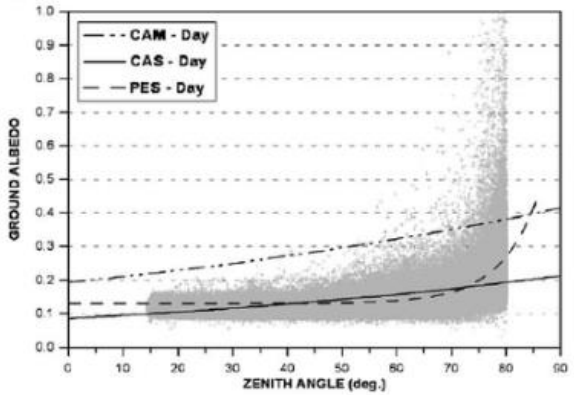
# Ground Albedo – Field Measurements

- Albedometer measurements




- Spectral & incidence angle response




- Published albedo data

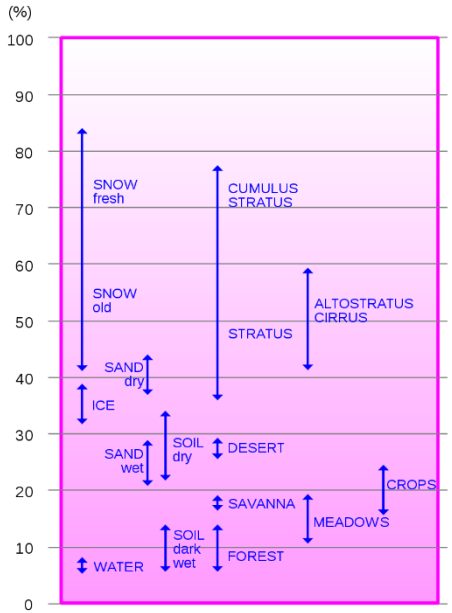
| Surface | Typical albedo |
|---|---|
| Fresh asphalt | 0.04[4] |
| Open ocean | 0.06[5] |
| Worn asphalt | 0.12[4] |
| Conifer forest (Summer) | 0.08,[6] 0.09 to 0.15[7] |
| Deciduous trees | 0.15 to 0.18[7] |
| Bare soil | 0.17[8] |
| Green grass | 0.25[8] |
| Desert sand | 0.40[9] |
| New concrete | 0.55[8] |
| Ocean ice | 0.5–0.7[8] |
| Fresh snow | 0.80–0.90[8] |

| Surface | Albedo |
|---|---|
| Soil | 0.05 - 0.40 |
| Sand | 0.15 - 0.45 |
| Grass | 0.16 - 0.26 |
| Agricultural Crops | 0.18 - 0.25 |
| Tundra | 0.18 - 0.25 |
| Forest | 0.05 - 0.20 |
| Water | 0.03 - 1.00 |
| Snow | 0.40 - 0.95 |
| Ice | 0.20 - 0.45 |
| Clouds | 0.30 - 0.90 |

**Figure 2** *Albedo values for various Earth surfaces. Adapted from www.eoearth.org.*

Ground Surface Albedo Values

| Surface type | Albedo |
|---|---|
| Green field (grass) | 23% |
| Concrete | 16% |
| White-painted concrete | 60%–80% |
| White gravel | 27% |
| White roofing metal | 56% |
| Light-gray roofing membrane | 62% |
| White roofing membrane | >80% |

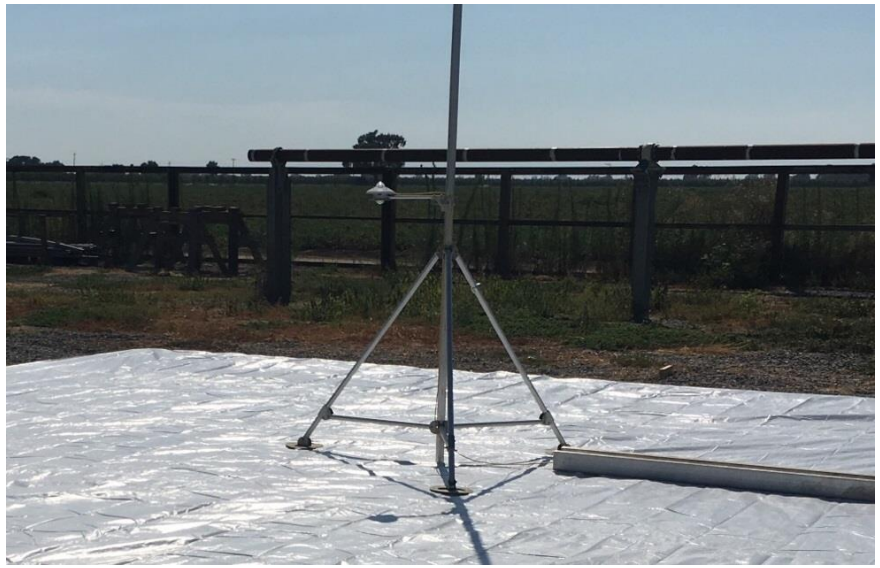


# Objectives

1. *Demonstrate two methods for obtaining and evaluating localized ground albedo*
2. *Share ground albedo measurements from three different test facilities*
3. *Calibrate expectations for albedo conditions at installation sites*

# Ground Albedo – Measurement Methods

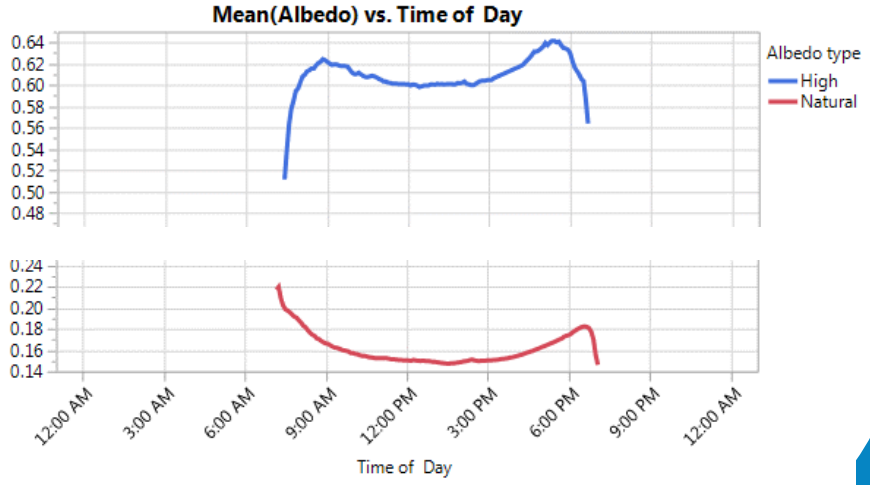
- Pyranometer measurements
  - Dual thermopile pyranometers
- Reference cell measurements
  - Two Standard SunPower IBC cells assembled back-to-back in a glass-glass coupon
- Site considerations
  - Low sensitivity to mounted height
  - Low sensitivity to mounting extension
  - Surface under albedometer modified with seasonal changes to ground conditions



# Ground Albedo – Field Measurements

## SunPower R&D Ranch - Davis, CA

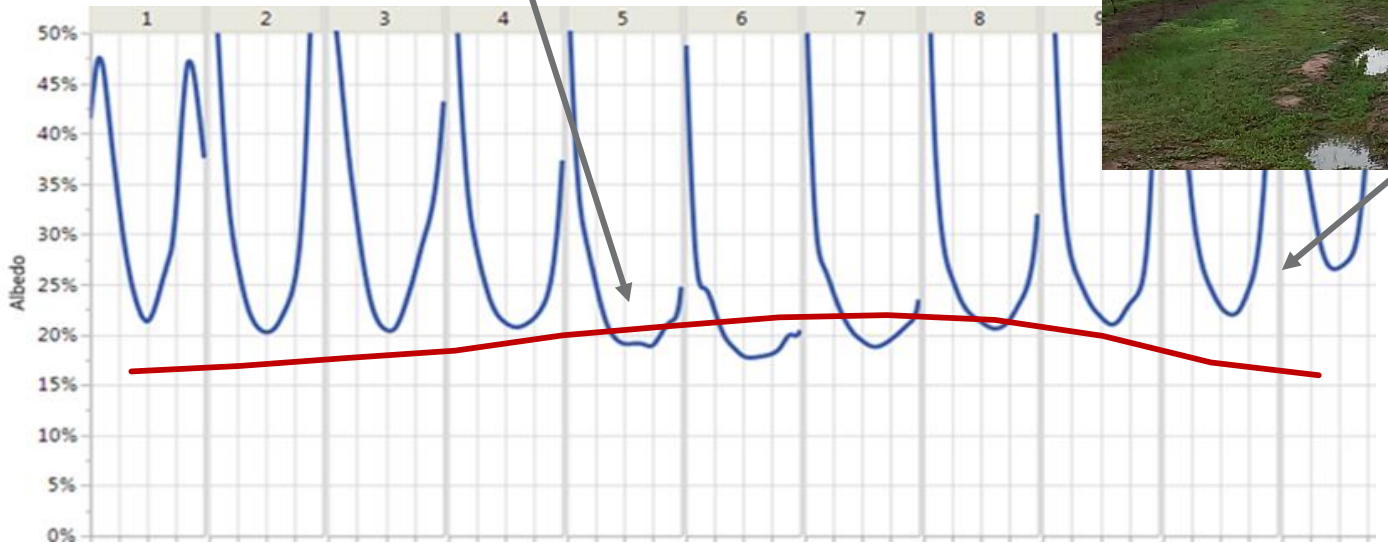
- Albedometer
  - Dual Kipp & Zonen CMP11
- Ground cover & Albedo
  - Dry compacted gravel: 15-18%
  - White ground cloth: 60-64%
- Published Albedo
  - Worn asphalt/gravel: 12-33%
  - Snow/white painted surface: 60-90%
- NSRDB Albedo
  - Pre-test site (dirt): 14-18%
- Potential Albedo error
  - Davis Site: 0-18%
  - Winter: 0-30%



# Ground Albedo – Field Measurements

## Sacramento, CA

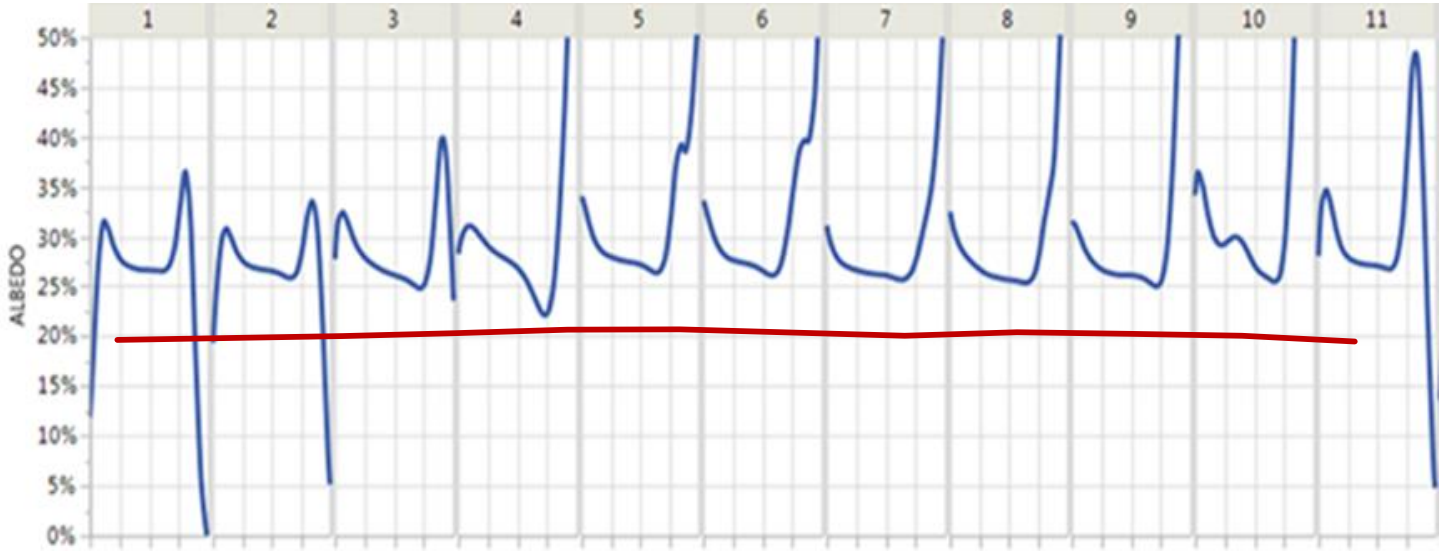
- Albedometer
  - Dual Kipp & Zonen CMP11
- Ground cover & Albedo
  - Summer – Straw base (dry): 18-23%
  - Winter – Dirt/Grass: 25-30%
- Published Albedo
  - Dry grass: 28-33%
  - Green grass: 16-26%
- NSRDB Albedo
  - Summer: 20-22%
  - Winter: 15-20%
- Potential Albedo error
  - Summer: 0-10%
  - Winter: 5-15%



# Ground Albedo – Field Measurements

## TEP – Tuscon, AZ

- Albedometer
  - Reference cell
- Ground cover
  - Dirt/Weeds (dry): 25-30%
- Published Albedo
  - 15-35%
- NSRDB Albedo
  - 20-22%
- Potential Albedo error
  - 10-15%



# Summary & Conclusions

- Albedo varies throughout the day with sun angle
- Albedo varies seasonally with changes in moisture, ground vegetation
- Published data show large ranges of constant albedo values

➢ *Local field measurements are important for characterizing local albedo variation*

- Errors in assumed ground albedo can result in up to ~5% error in annual bifacial gain
- Typical measurements don't account for lower albedo in shaded areas
- Seasonal variation at project site (temperatures, moisture, shade, etc.)
- Potential ground-cover changes at project site (vegetation, soiling, etc.)

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# Thank You

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