Reference Cell Performance and Modeling on a One-Axis Tracking Surface

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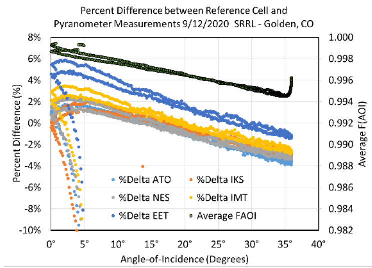
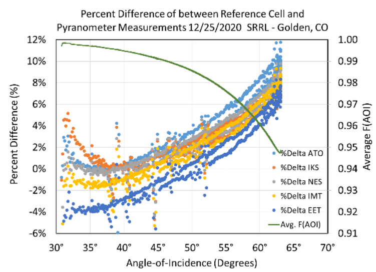
Introduction

- Examine behavior of reference cells on a one-axis tracking surface
- Model reference cell output using spectral data and reference cell responsivity
- Percent difference between reference cell measurements and pyranometer measurements (CMP 22)
  - Demonstrates the need to specify standard conditions for calibrations and comparisons.





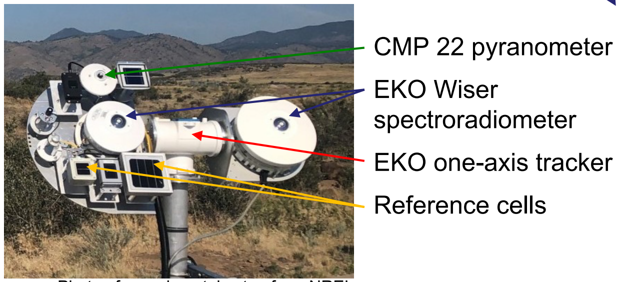


Photo of experimental setup from NREL

Objectives

1. Show model developed for a two-axis tracking surface works on a one-axis tracking surface
2. Examine the how model performs under various:
   - angle-incidence conditions
   - changes in incoming spectral irradiance
   - reference cell temperatures
3. Examine model using five different reference cells over entire year
4. Lay basis to relate reference cell measurements to irradiance measurements

Reference Cell Model

$$RC_{model} = \frac{F(AOI)}{K} \sum_{\lambda=280nm}^{4000} R_\lambda(T) \cdot I_\lambda$$

- **F(AOI)**: Angle-of-incident function. The average transmission of light through the glazing
  - Weighted average of the F(AOI)'s for direct, circumsolar, dome, horizon, and ground reflected irradiance components. [2, 3]
- **K**: a constant. Similar to the responsivity of a pyranometer
- **R_λ(T)**: Spectral responsivity of the reference cell adjusted for temperature (T) [1]
- **I_λ** is the incident spectral irradiance at wavelength (λ)

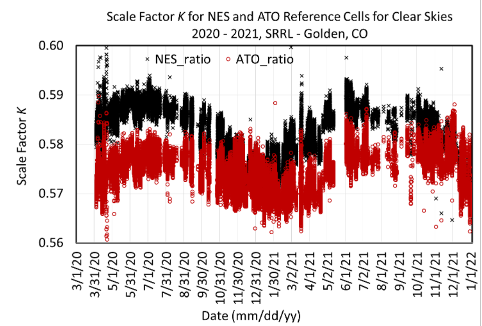
Results

$$K = \frac{F(AOI) \sum_{\lambda=280nm}^{4000} R_\lambda(T) \cdot I_\lambda}{RC_{measure}}$$

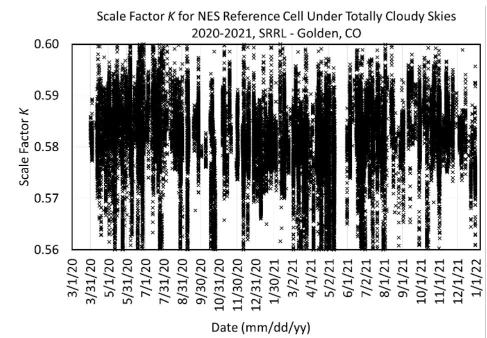
For an ideal model, K would be constant under all conditions.

One-minute reference cell *K* values on a one-axis tracking surface plotted over two years.

- Plots are representative of other reference cells



Under clear skies, there is a 1.7% variation in K throughout the year



Under totally cloudy skies, there is a 3% to 4% variation in K over the day

Conclusion

- Reference cell model successfully reproduces reference cell output within
  - **1.7% over the year (clear skies)**
  - **3 – 4% over the day (cloudy skies)**
- Model reference cell output using spectral data and reference cell responsivity
- **Incorporates**:
  - **Perez model** to estimate diffuse components
  - **Marion model** to calculate transmission through the glazing
  - **Hishikawa model** to adjust spectral responsivity to temperature changes

- **Influences to the model:**
- Spectral distribution changes are the dominant influence, especially in the winter
- Angle-of-Incident effects, F(AOI) span a variety of incident angles over the year.
- The influence of temperature less than 0.7%

Demonstrates uniform calibration methodology is needed to compare reference cells in the field

References / Acknowledgements

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