Geometric Spectral Albedo

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Irradiation components

- Direct
- Diffuse
- Albedo
Irradiation components

- Direct
- Diffuse
- Albedo
• The ratio between reflected upwelling radiation and the global downwelling radiation incident at the measurement surface.

\[ \alpha = \frac{\Phi_{down}^S}{\Phi_{up}^S} \]
Importance of albedo for PV

- TWp PV era is coming...
- 20% share for bifacial by 2022.
- Bifaciality is an option to increase the PV energy yield with low additional cost.
- For bifacials, contribution of albedo component of sunlight becomes more significant.

Up to 30% more energy for Amsterdam and even more

Depends on
1) bifacial factor
2) albedo value

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Accurate albedo modelling → Less error in yield prediction

Previous models

How should I model it?

- Beam/Diffuse albedo model
- Isotropy assumption model
- Temps & Coulson’s model
- Spectral albedo model
- Nkemdirim model
- Constant albedo assumption
- Average measured site albedo
- Zonal albedo model

Complexity in albedo modelling

- **Whatever** is in an environment may influence albedo and the environment is changing all the time, so does albedo.
- Light source condition is influential.
- Previous models are neither right nor wrong. They are incomplete.

Dependency of albedo on many factors makes it a huge challenge to fed all the influential parameters into one coherent model.
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Main influential factors

- Surrounding environment can be explained by two main features:
  - Material
  - Geometry
- On top of that, to model albedo, we have to consider light source features as well.
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Coherent albedo model

- Now let's put all of them together:

\[
\alpha = \sum_{i=1}^{i=N} R_i \left( C_i F_{S\rightarrow A_1} + \frac{1}{H+1} \left( C'_i F_{S\rightarrow A_1} + F_{S\rightarrow A_2} \right) \right)
\]

Coherent albedo model

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\[ \alpha \leq R \]
Put the model into test

- Experiment

- Simulation
  - Material
    - ASTER spectral library
  - Geometry
    - LiDAR data
    - Height map
    - 3D software packages
  - Weather
    - Meteorological stations
    - Irradiation models
  - Albedo equation
Albedo model validation

- Low RMSEs of 0.012 and 0.032
  good agreement between prediction and measurement.
Applications of the proposed albedo equation

- Remote Sensing
- Local and Global Warming
- Geology and Agriculture
- Energy and Photovoltaics
- Computer Graphics
- Conceptual Application
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Applications of the proposed albedo model

- Energy and Photovoltaics
  - Overestimation of \((33 \text{ kWh/m2/year} \times \text{average albedo before installation})\) in DC-yield prediction.

avoiding energy yield over-estimation
Summary of results

- A coherent model to cluster all the parameters which affect albedo in one equation.

\[ \alpha = \sum_{i=1}^{i=N} R_i \left( C_i F_{S \to A_1} + \frac{1}{H+1} \left( C_i' F_{S \to A_1} + F_{S \to A_2} \right) \right) \]

- The model can calculate the albedo without the need for in-field measurements.

- The model can be deployed in many fields of research concerned with urban and solar energy.
Thank you for your attention

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