On the Relationship Between Ground- and Satellite- Based Global Horizontal Irradiance

Mayank Jain¹,², Deepak Joel Yericherla³, and Soumyabrata Dev¹,²

¹ The ADAPT SFI Research Centre, Dublin, Ireland
² School of Computer Science, University College Dublin, Ireland
³ International Institute of Information Technology Naya Raipur, Chhattisgarh, India

Send correspondence to S.Dev, e-mail: soumyabrata.dev@ucd.ie
Introduction

Global Horizontal Irradiance (GHI): The total amount of solar energy that reaches a horizontal surface on the earth.

- GHI is essential to the very existence of life on the earth.
- GHI also determines the amount of solar power that is generated from solar cells.
- Hence, it is important to analyze and forecast the exact values of GHI.
Introduction

- Global Horizontal Irradiance (GHI): The total amount of solar energy that reaches a horizontal surface on the earth.
- GHI is essential to the very existence of life on the earth.
- GHI also determines the amount of solar power that is generated from solar cells.
- Hence, it is important to analyze and forecast the exact values of GHI.
Introduction

• Global Horizontal Irradiance (GHI): The total amount of solar energy that reaches a horizontal surface on the earth
• GHI is essential to the very existence of life on the earth
• GHI also determines the amount of solar power that is generated from solar cells
• Hence, it is important to analyze and forecast the exact values of GHI
Introduction

Global Horizontal Irradiance (GHI): The total amount of solar energy that reaches a horizontal surface on the earth.

- GHI is essential to the very existence of life on the earth.
- GHI also determines the amount of solar power that is generated from solar cells.
- Hence, it is important to analyze and forecast the exact values of GHI.
Motivation

- GHI values can be obtained from the following:
  - Satellite-based sensors
  - Ground-based sensors
- Satellites are cost effective, and cover large areas including remote locations
- However, satellites have been noted to give biased estimations
- Hence, this paper analyzes the relationship between satellite and ground-based sensor readings of GHI
- The paper further attempts to model ground-based GHI readings from the satellite data
Motivation

- GHI values can be obtained from the following:
  - Satellite-based sensors
  - Ground-based sensors
- Satellites are cost effective, and cover large areas including remote locations
  - However, satellites have been noted to give biased estimations
- Hence, this paper analyzes the relationship between satellite and ground-based sensor readings of GHI
- The paper further attempts to model ground-based GHI readings from the satellite data
Motivation

- GHI values can be obtained from the following:
  - Satellite-based sensors
  - Ground-based sensors
- Satellites are cost effective, and cover large areas including remote locations
- However, satellites have been noted to give biased estimations
- Hence, this paper analyzes the relationship between satellite and ground-based sensor readings of GHI
- The paper further attempts to model ground-based GHI readings from the satellite data
Motivation

- GHI values can be obtained from the following:
  - Satellite-based sensors
  - Ground-based sensors
- Satellites are cost effective, and cover large areas including remote locations
- However, satellites have been noted to give biased estimations
- Hence, this paper analyzes the relationship between satellite and ground-based sensor readings of GHI
- The paper further attempts to model ground-based GHI readings from the satellite data
Motivation

- GHI values can be obtained from the following:
  - Satellite-based sensors
  - Ground-based sensors
- Satellites are cost effective, and cover large areas including remote locations
- However, satellites have been noted to give biased estimations
- Hence, this paper analyzes the relationship between satellite and ground-based sensor readings of GHI
- The paper further attempts to model ground-based GHI readings from the satellite data
Data Analysis

Actual GHI values as obtained from ground-based sources - Solcast website

GHI values as provided in estimates from satellites - ERA5 reanalysis dataset

Difference between ground- and satellite-based observations.

A linear relationship can be seen between the readings of the two sources.
Data Analysis (contd.)

Daily mean difference between satellite and ground-based sensor data as obtained for different months in 2020

Such huge variations over months indicate that different models should be trained for different months.
Variation in daily mean GHI values from ground- and satellite- based sources for the month of August from 2014 to 2020.
For fair comparison, all such timestamps were removed where either of the ground- or satellite-based readings were 0 (indicative of nighttime). Number of remaining daytime data points that were available for each month accumulated from 2014 – 2020 are shown above.
Model Training

- Different models are required for different months
- Linear regression models were chosen since a linear relationship was indicated in the initial analysis
- For a particular day, significant variations in GHI values was noted. Hence, timestamp was provided in the model’s input in the form of one-hot encoded vectors.
- Coefficient of determination ($R^2$) was used to evaluate model’s performance.
Regression Results

Regression over the month of January

Regression over the month of June

Scatter plot showing the satellite readings and the corresponding ground-based sensor readings in the test set. The line through the center shows the linear regression fit on the data.
Objective Evaluation

Coefficient of determination Values for each month
Conclusions and Future Work

- Conclusions and contributions:
  - A systematic analysis of ground- and satellite- based datasets of GHI is presented
  - Noted that satellite estimations are generally significantly off than the true ground-level observations
  - Recommended to create different models for different months of the year
  - Shown that a near linear relationship exists between the ground-based values and satellite estimations.

- Future work:
  - Consider a complex model to better approximate the ground-based readings from the satellite data
  - Study the generalizability of the identified models and/or the approach for different locations on the earth
Conclusions and Future Work

- Conclusions and contributions:
  - A systematic analysis of ground- and satellite-based datasets of GHI is presented
  - Noted that satellite estimations are generally significantly off than the true ground-level observations
  - Recommended to create different models for different months of the year
  - Shown that a near linear relationship exists between the ground-based values and satellite estimations.

- Future work:
  - Consider a complex model to better approximate the ground-based readings from the satellite data
  - Study the generalizability of the identified models and/or the approach for different locations on the earth
Conclusions and Future Work

- Conclusions and contributions:
  - A systematic analysis of ground- and satellite- based datasets of GHI is presented
  - Noted that satellite estimations are generally significantly off than the true ground-level observations
  - Recommended to create different models for different months of the year
  - Shown that a near linear relationship exists between the ground-based values and satellite estimations.

- Future work:
  - Consider a complex model to better approximate the ground-based readings from the satellite data
  - Study the generalizability of the identified models and/or the approach for different locations on the earth
Conclusions and Future Work

• Conclusions and contributions:
  • A systematic analysis of ground- and satellite- based datasets of GHI is presented
  • Noted that satellite estimations are generally significantly off than the true ground-level observations
  • Recommended to create different models for different months of the year
  • Shown that a near linear relationship exists between the ground-based values and satellite estimations.

• Future work:
  • Consider a complex model to better approximate the ground-based readings from the satellite data
  • Study the generalizability of the identified models and/or the approach for different locations on the earth
Conclusions and Future Work

• Conclusions and contributions:
  • A systematic analysis of ground- and satellite- based datasets of GHI is presented
  • Noted that satellite estimations are generally significantly off than the true ground-level observations
  • Recommended to create different models for different months of the year
  • Shown that a near linear relationship exists between the ground-based values and satellite estimations.

• Future work:
  • Consider a complex model to better approximate the ground-based readings from the satellite data
  • Study the generalizability of the identified models and/or the approach for different locations on the earth
Conclusions and Future Work

• Conclusions and contributions:
  • A systematic analysis of ground- and satellite- based datasets of GHI is presented
  • Noted that satellite estimations are generally significantly off than the true ground-level observations
  • Recommended to create different models for different months of the year
  • Shown that a near linear relationship exists between the ground-based values and satellite estimations.

• Future work:
  • Consider a complex model to better approximate the ground-based readings from the satellite data
  • Study the generalizability of the identified models and/or the approach for different locations on the earth
Conclusions and Future Work

- **Conclusions and contributions:**
  - A systematic analysis of ground- and satellite-based datasets of GHI is presented
  - Noted that satellite estimations are generally significantly off than the true ground-level observations
  - Recommended to create different models for different months of the year
  - Shown that a near linear relationship exists between the ground-based values and satellite estimations.

- **Future work:**
  - Consider a complex model to better approximate the ground-based readings from the satellite data
  - Study the generalizability of the identified models and/or the approach for different locations on the earth
Conclusions and Future Work

• Conclusions and contributions:
  • A systematic analysis of ground- and satellite- based datasets of GHI is presented
  • Noted that satellite estimations are generally significantly off than the true ground-level observations
  • Recommended to create different models for different months of the year
  • Shown that a near linear relationship exists between the ground-based values and satellite estimations.

• Future work:
  • Consider a complex model to better approximate the ground-based readings from the satellite data
  • Study the generalizability of the identified models and/or the approach for different locations on the earth
Thank you for your attention!¹

¹https://github.com/ydjoel/SolarSatGround