

Satellite 2015

Comparison Analysis of Global Horizontal Irradiance between Korea Institute of Energy Research and NASA

Shin-Young Kim

Korea Institute of Energy Research (KIER)
Korea University
2015. 8. 17.



1

Introduction

- **Research Objectives**
- **Definition of Global Horizontal Irradiance (GHI)**
- **Solar Monitoring History in KIER**

Introduction

- **Research Objective: Reliability verification for the ground- measured data in KIER compared with the satellite derived data in NASA**
- More specifically,
 - Proposing a predictable formula for the global solar radiation data measured in KIER related to the satellite derived data in NASA
 - Forecasting global solar radiation for the areas not measured in Korea compared with the ground-measured data in KIER
 - Providing a basic data in compiling reliable database for the global solar radiation values in solar technology development

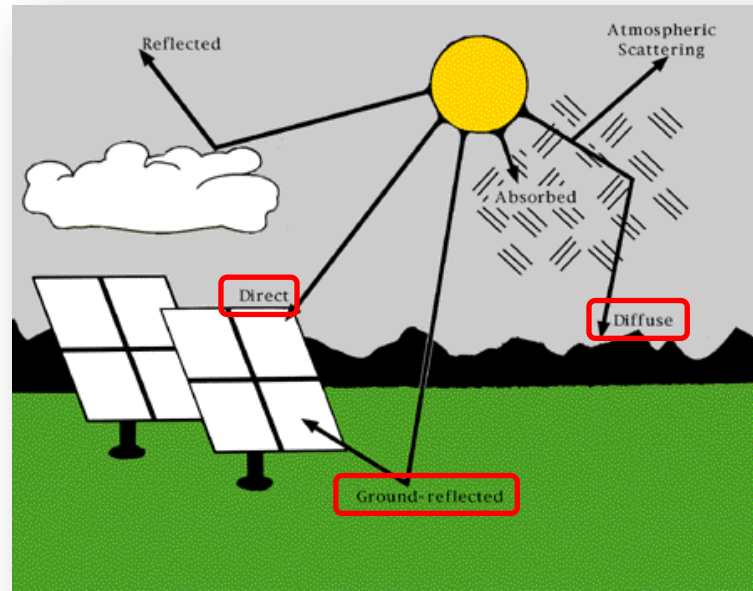
Introduction

- **Global Horizontal Irradiance (kWh/m²/day)**

- Amount of electromagnetic energy (solar radiation) incident on the surface of the earth.
Also referred to as total or global solar radiation
- The sum of Direct Normal Irradiance (DNI), Diffuse Horizontal Irradiance (DHI), and ground-reflected radiation

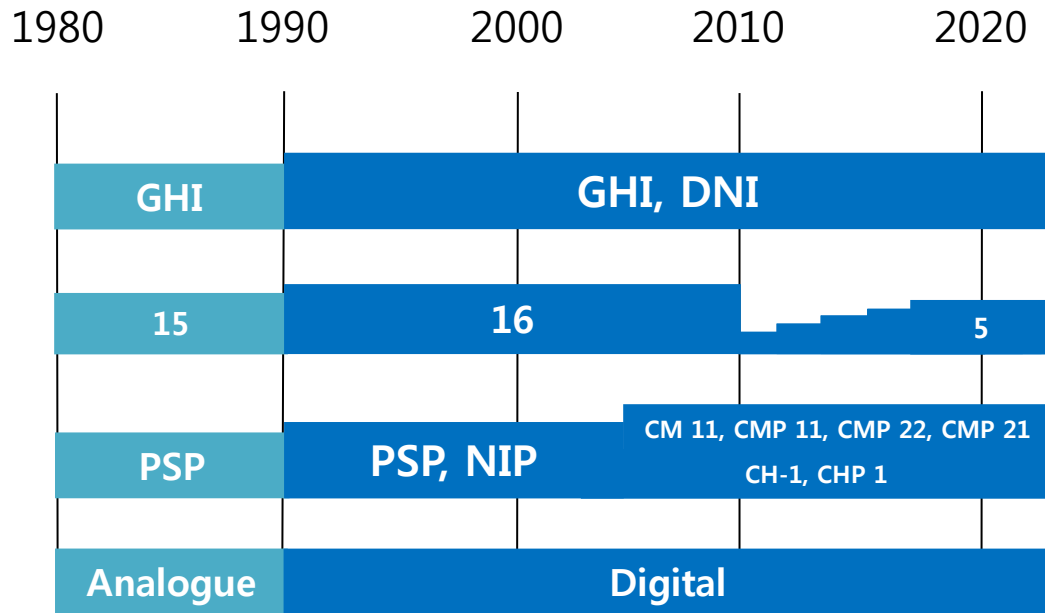
$$\text{GHI} = \text{DHI} + \text{DNI} \cdot \cos(Z)$$

Z: solar zenith angle



1 Introduction

• Solar Monitoring History in KIER



▲ Solar Monitoring History in KIER and South Korea Solar Radiation Monitoring Stations

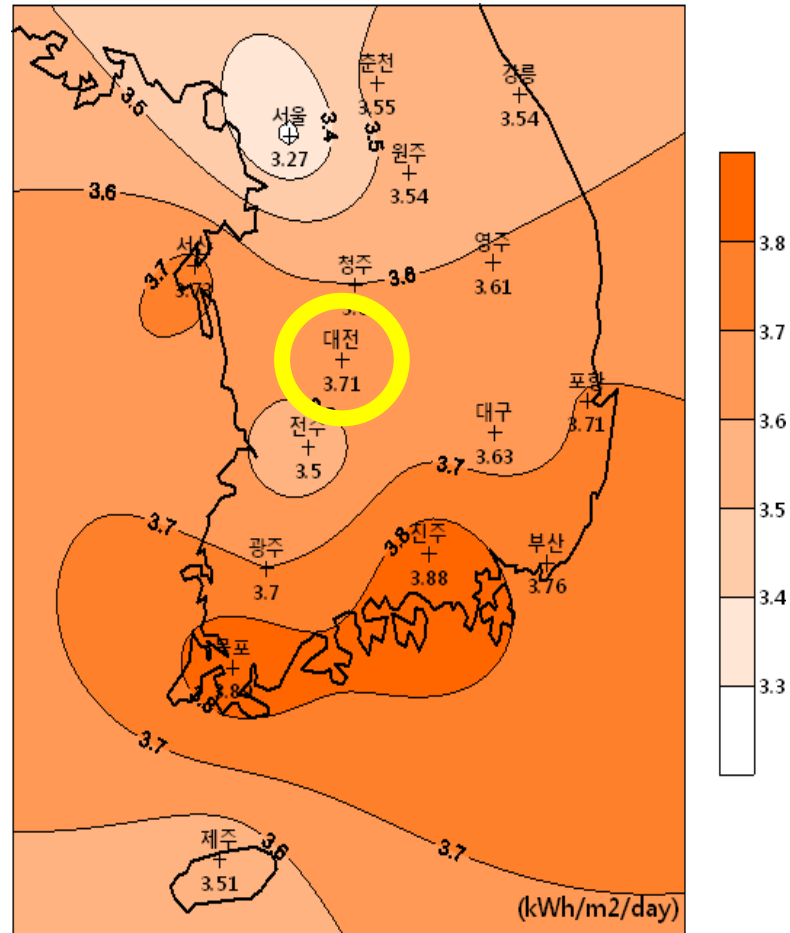


2

Research Method

- **Research Area, Daejeon**
- **Data Information and Measuring GHI Values in KIER and in NASA**
- **KIER**
 - **Solar Radiation Data Measurement and Collection Method**
 - **Solar Radiation Measurement**
- **NASA**
 - **Overview of NASA Data Used to Derive Parameters in SSE Release 6.0**
- **Statistical Analysis**

- Research Area, Daejeon - Lat.(N) 36° 22', Long.(E) 127° 22'

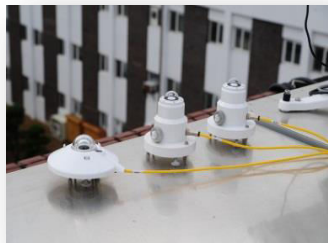
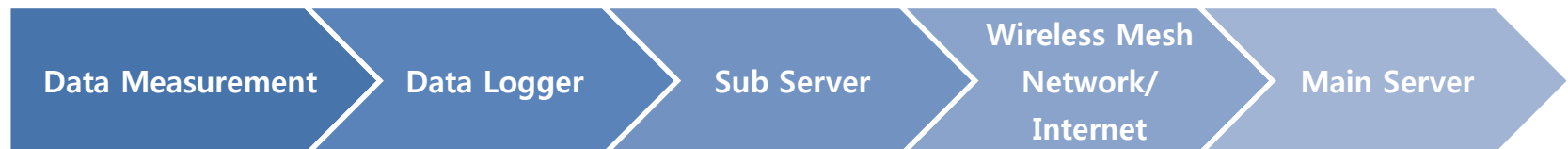


▲ Daily Average GHI Resource Map of South Korea

- **Data Information and Measuring GHI Values in KIER and in NASA**

Classification		Content	
Period		1992. 1. 1 ~ 2005. 6. 30	
Data Type		Daily Average of GHI	
Measuring Method	KIER	Ground	Model PSP of the EPPLEY Laboratory, Inc. (EPLAB)
	NASA	Satellite	Surface Radiation Budget (SRB) portion of NASA's Global Energy and Water Cycle Experiment (GEWEX) - The current SRB archive is Release 3.0

• KIER - Solar Radiation Data Measurement and Collection Method



Data Measurement



Data Logger

• Server

- KIER Data



• Sub Server

- Korea Institute of Ocean Science and Technology (KIOST), National Meteorological Satellite Center (NMSC) Data

• Hard Disk

- Korea Meteorological Administration (KMA) Data

▲ Data Measurement and Collection Procedure

Research Method

• KIER - Solar Radiation Measurement

- Solar Radiation Measurement Depending on Meteorological
- Solar Radiation Measurement Depending on Ingredient
- Solar Radiation Measurement Depending on Slope
- Measurement Depending on Wavelength and Meteorological



▲ Measurement Status of Total Solar Radiation Resource of Laboratory

• NASA - Overview of NASA Data Used to Derive Parameters in SSE Release 6.0

Programs Contributing to SSE Release 6.0

SSE Archive

NASA/ISCCP &
CERES/MODIS



NASA GEWEX/SRB
Release 3.0



Daily averaged
parameters
(July 1, 1983 –
June 30, 2005)

- TOA Radiance, Clouds, and Surface Parameters

- Global estimates of the solar and thermal infrared wavelength radiation at earth's surface and top of atmosphere

1. Top of atmosphere insolation
2. Shortwave (solar, 0.2-4.0 μm) insolation incident on a horizontal surface at the Earth's surface
3. Longwave (thermal infrared, 4.0-100 μm) radiative flux incident on a horizontal surface at the Earth's surface
4. Clear sky insolation on a horizontal surface at the Earth's surface

Research Method

- **Statistical Analysis : MBE, RMSE, and Regression Analysis**

- Daily Avg., Monthly Avg., and Annual Avg. GHI data measured in KIER and derived in NASA were treated statistically using Bias (%) and RMSE (%) to determine the errors .

$$MBE \text{ (Mean Bias Error)} = \frac{1}{n} \sum_{i=1}^n \frac{x_i - x_{true}}{x_{true}}$$

$$RMSE \text{ (Root Mean Square Error)} = \sqrt{\frac{1}{n} \sum_{i=1}^n \left(\frac{x_i - x_{true}}{x_{true}} \right)^2}$$

x_i : GHI of NASA (kWh/m²/day)

x_{true} : GHI of KIER (kWh/m²/day)

- Simple regression analysis was used to predict the relations in GHI values between measured in KIER and derived in NASA.

3

Results

- **Comparison in GHI values between measured in KIER and derived in NASA using Bias and RMSE for the time period of January 1, 1992- June 30, 2005**
- **Comparison and Relationship in Daily Avg. GHI Values between KIER and NASA**
- **Comparison and Relationship in Monthly Avg. GHI Values between KIER and NASA**
- **Comparison and Relationship in Annual Avg. GHI Values between KIER and NASA**

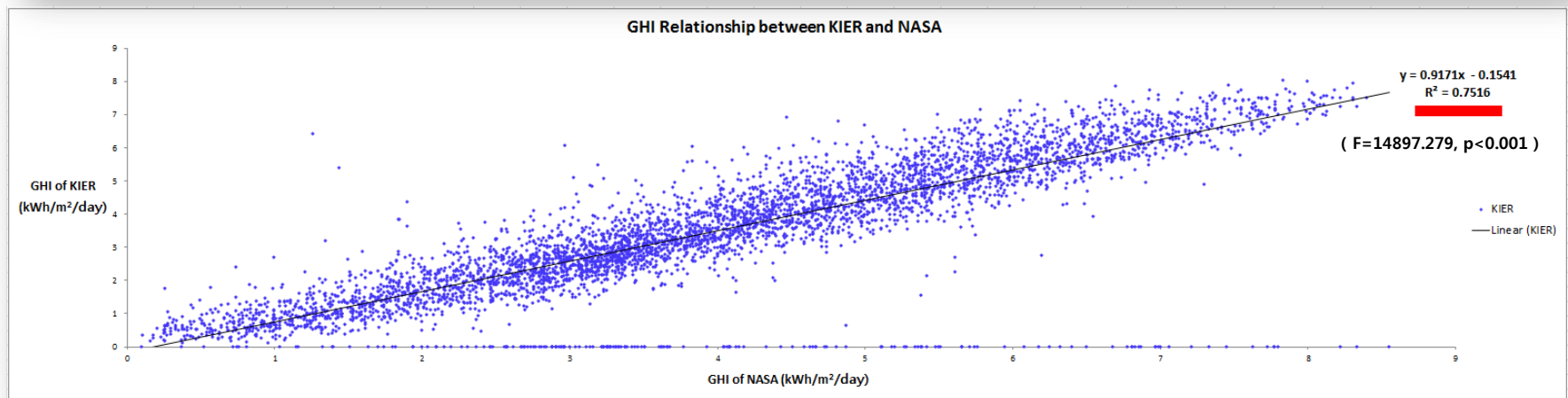
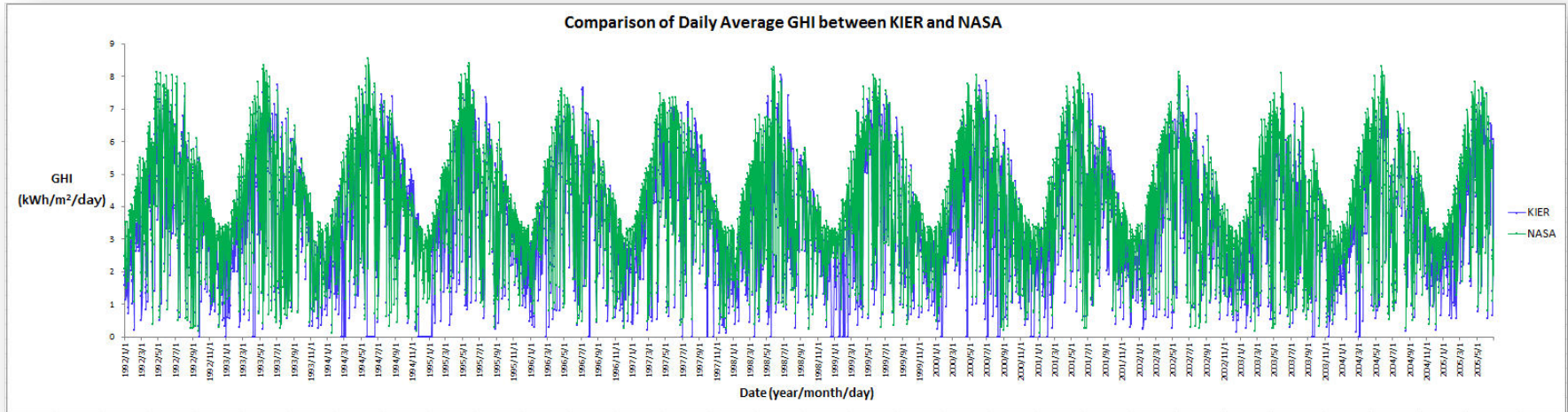
- Comparison in GHI values between measured in KIER and derived in NASA using Bias and RMSE for the time period of January 1, 1992-June 30, 2005

Parameter	Average GHI (kWh/m ² /day)		Bias (%)	RMSE (%)
	KIER	NASA		
Daily Average GHI	3.53	4.01	17.55	42.53
Monthly Average GHI			17.79	33.51
Annual Average GHI			13.90	14.64

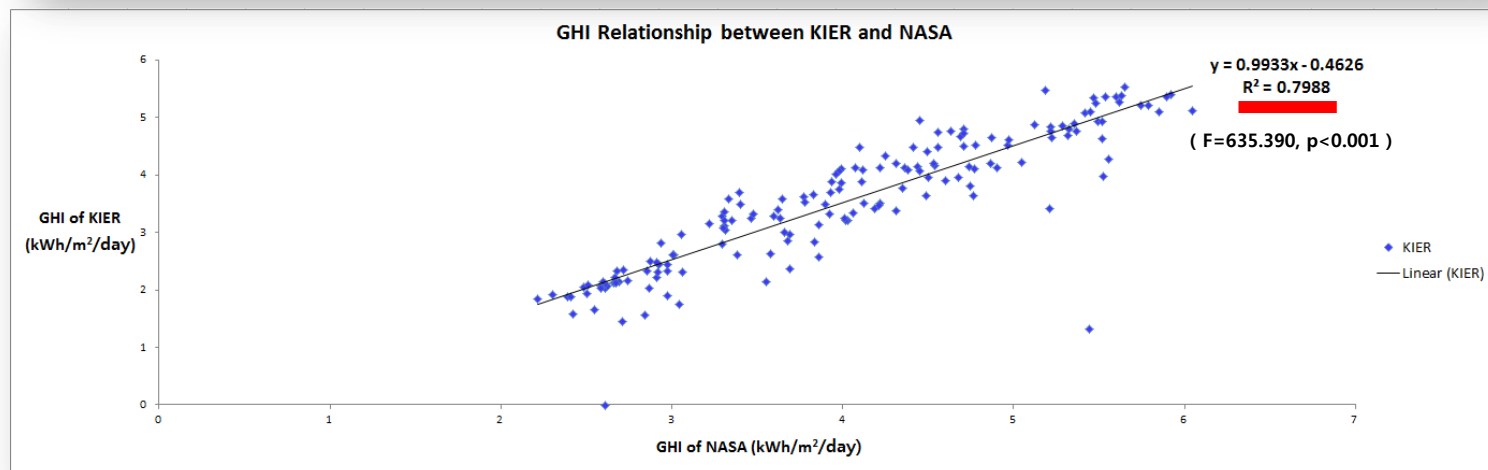
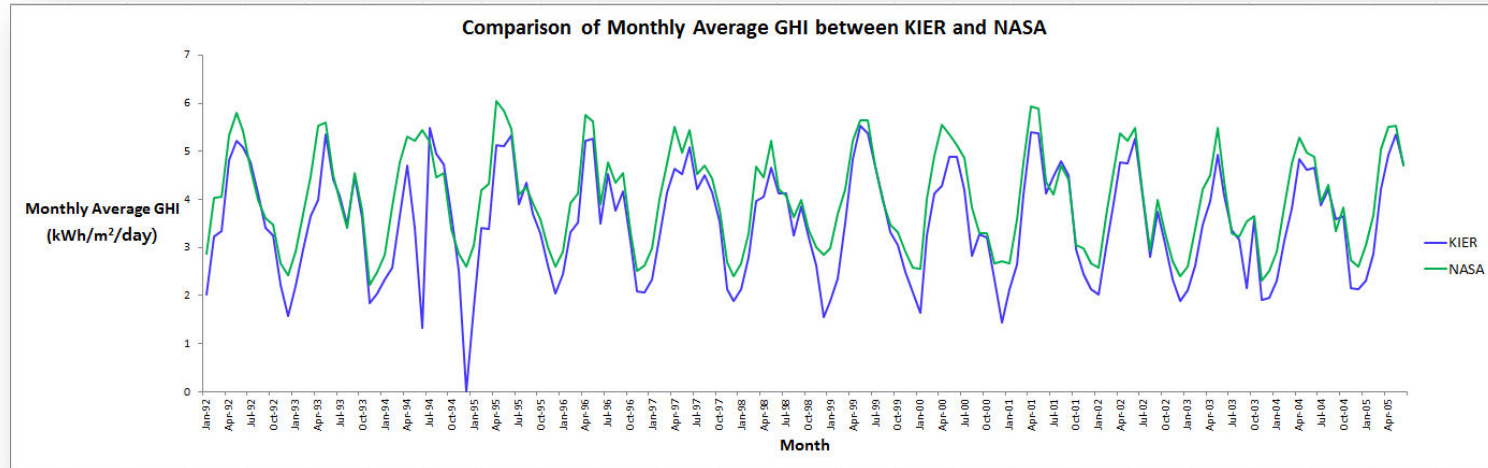
- cf.) SSE versus BSRN (Baseline Surface Radiation Network) Daily Average GHI for the Time Period of January 1, 1992 - June 30, 2005

Parameter	Region	Bias (%)	RMSE (%)
Daily Average GHI	Global	-1.58	20.57

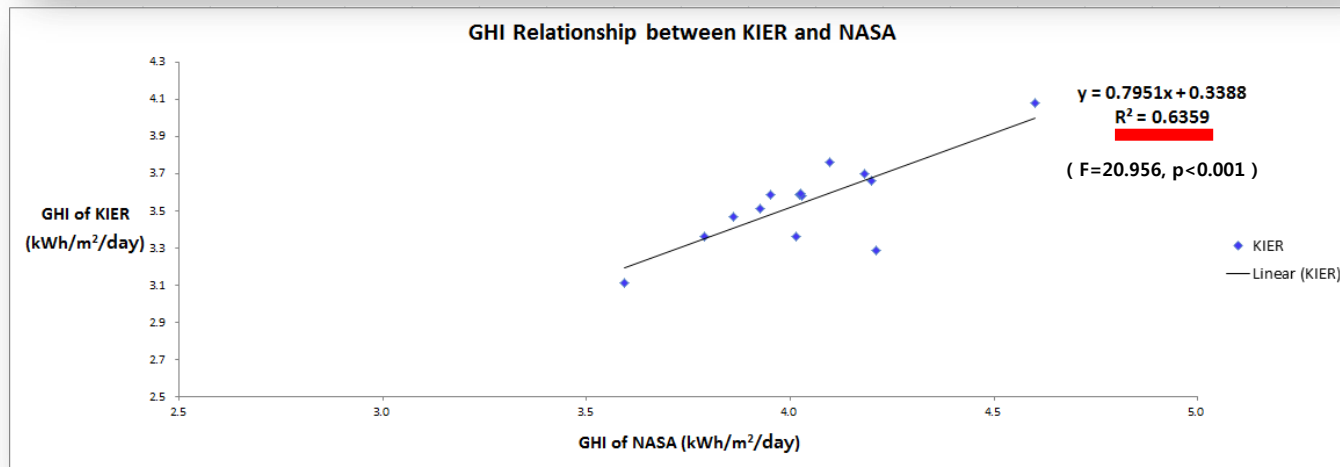
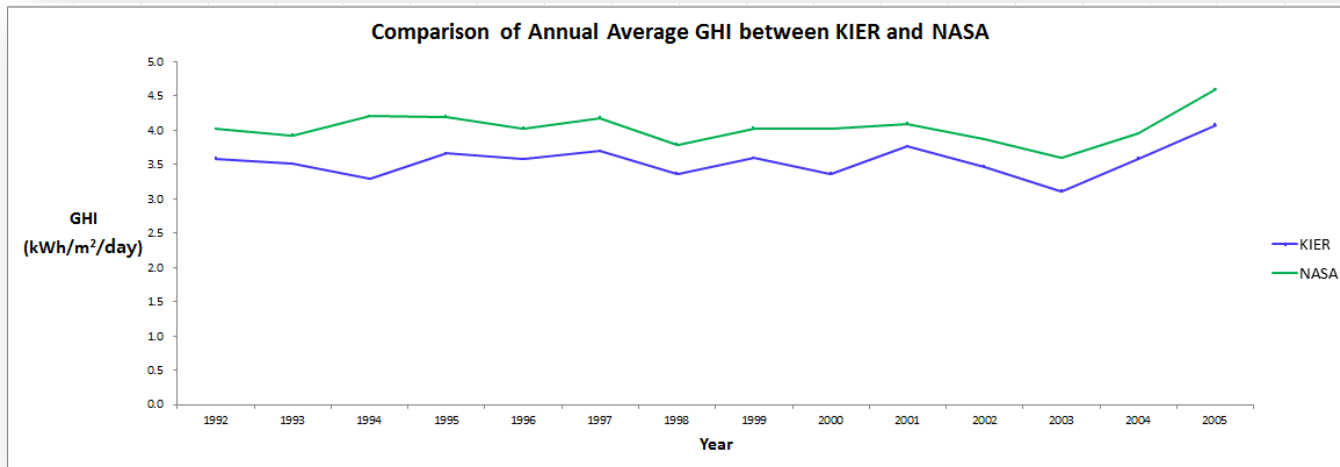
- Comparison and Relationship in Daily Avg. GHI Values between KIER and NASA



- Comparison and Relationship in Monthly Avg. GHI Values between KIER and NASA



- Comparison and Relationship in Annual Avg. GHI Values between KIER and NASA





4

Conclusion



Conclusion

- Daily average GHI values measured in KIER and those derived from NASA for thirteen and half years was 3.53 kWh/m²/day and 4.01 kWh/m²/day , respectively.

And, daily average GHI value for KIER seemed to be a little lower than the value from NASA.

- Results of statistical analyses using Mean Bias Error(MBE) and Root Mean Square Error(RMSE) showed that the relatively large errors existed among the values between KIER and NASA, and the errors in daily average GHI value between KIER and NASA appeared to be great compared with monthly, and annual average value .

- Results of statistical analyses using simple regression analysis showed that approximately 75% of variation of GHI values in KIER could be explained by the regression line, and the line was fitted well.($p < 0.001$). Approximately 80% of variation in monthly average values and 64% of variation in annual average values in KIER could be explained by the regression line. The regression line was also fitted well.($p < 0.001$). These results indicated that significant relationship existed in the GHI values between KIER and NASA, and GHI value variations in KIER could be explained by the regression models. Thus, it could be suggested that the ground- measured data in KIER have reliable verification compared with the satellite-derived data from NASA.

THANKS FOR YOUR LISTENING

Global **KIER**

Comparison Analysis of GHI between KIER and NASA

