Climate Change Test Reference Years for South Korea

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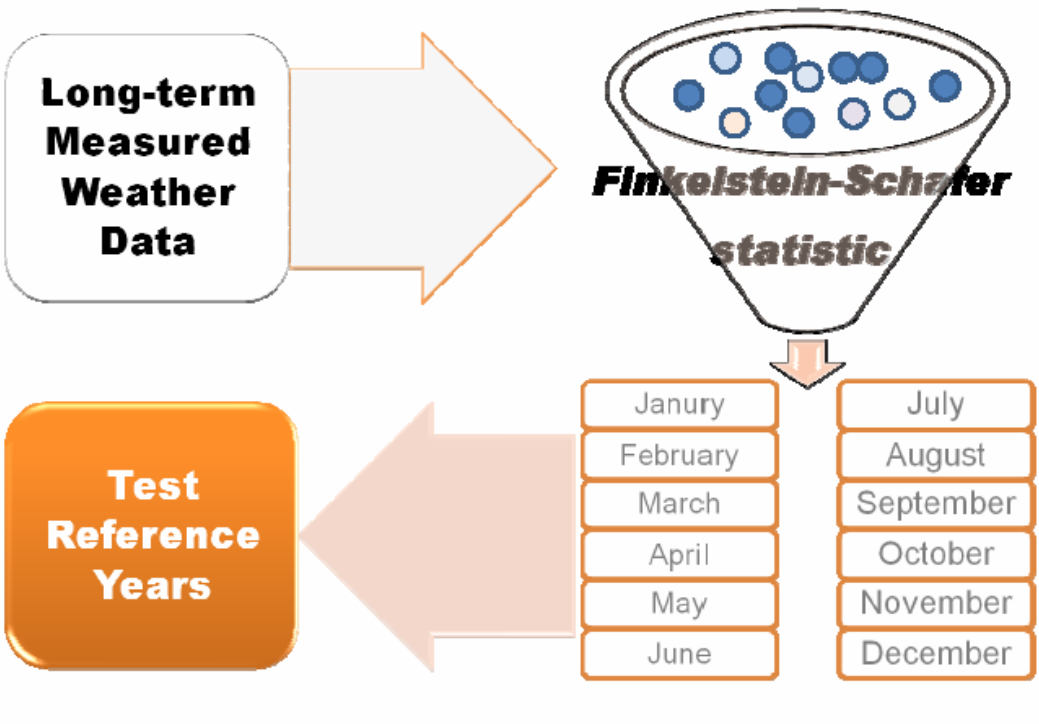
Introduction

- This research discusses recent Hadley Centre climate simulation and the sources of relevant data series for South Korea.
- Therefore climate change data is needed to assess the future performance of building design and solar energy systems built now.
- For the appropriate and accurate design of solar energy conversion and utilization devices, an accurate knowledge of the solar radiation data is of vital importance.
- A test reference year (TRY) is available for energy analyses and design assessments.
- TRY methodologies use different algorithms and typical months are select ed in a way that the monthly average, standard deviation and the sequence o f daily parameters of the TRY are close to the corresponding values of long-term measured data series.
- Some measured results are discussed from the South Korea HadCM3 model from which Test Reference Years for 1981~2000, 2005~2024, 2030~2049, 2080~2099 have been derived.

Methodology



Methodology

- CDF (cumulative frequency distribution)

$$Sn(X) = \begin{cases} 0 & \text{for } x < x_1 \\ (k - 0.5)/n & \text{for } x_k < x < x_{k+1} \\ 1 & \text{for } x > x_k \end{cases}$$

- Finkelstein-Schafer statistics are the common methodology for generating typical weather data.

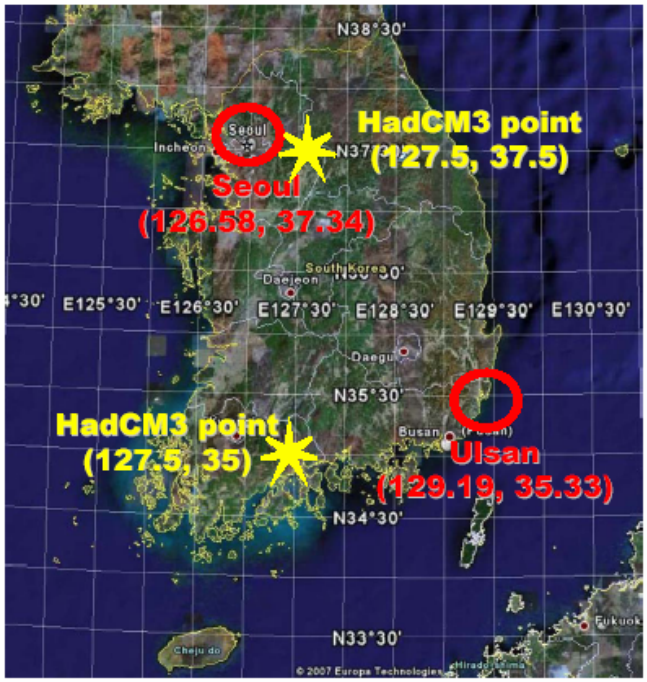
(1) $FS_{(y,m)} = (1/n)\sum_{i=1}^{n} |CDF_m(x_i) - CDF_{y,m}(x_i)|$

(2) $TRY = \min(FS)$

Methodology

- The Hadley Centre model (HadCM3) are two grid boxes that cover the majority of land area of the South Korea, one for the south of Korea(127.5, 35), one for the middle of Korea(127.5, 37.5).

- Seoul (126.58, 37,34)
- Ulsan (129.19, 35.33)



Methodology

- Real observed weather data from the weather stations at Ulsan and Seoul (1961–2005) are used to test how well HadCM3 (south and middle Korea grid box) models recent Ulsan and Seoul solar irradiance.

- In HadCM3, one of the solar radiation parameters is downward short-wave flux (DSWF).

Results and Discussion

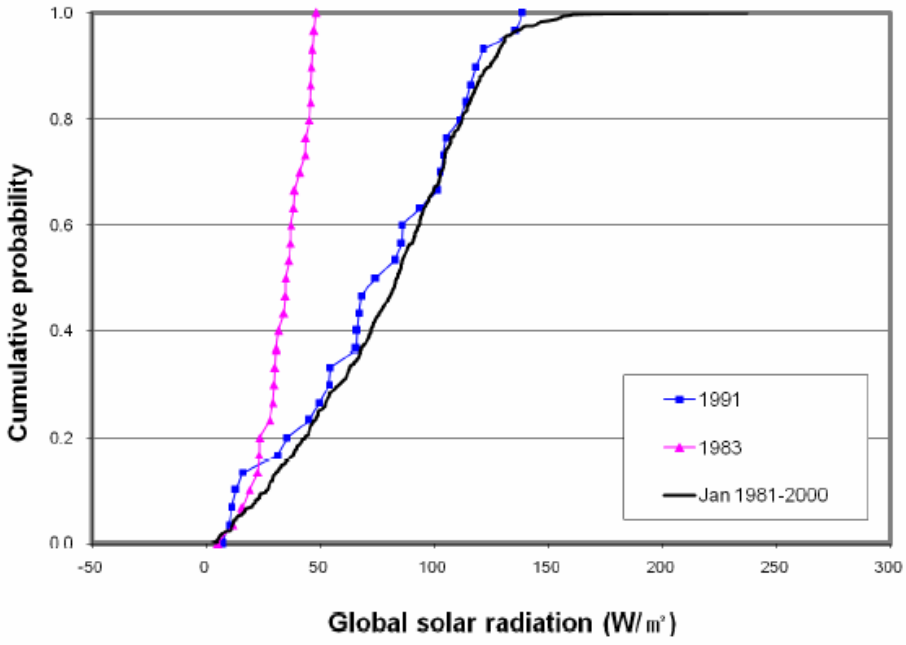
FS values for January data from Seoul (1981-2000)

FS values and year ranks for daily solar radiance for January

Year	FS values	Rank	Year	FS values	Rank
1981	0.141581	14	1991	0.035968	1
1982	0.076936	8	1992	0.091258	10
1983	0.350742	20	1993	0.072387	6
1984	0.037839	2	1994	0.049613	4
1985	0.214452	17	1995	0.110742	12
1986	0.214871	18	1996	0.076355	9
1987	0.11629	13	1997	0.042742	3
1988	0.150032	15	1998	0.050613	5
1989	0.183226	16	1999	0.073000	7
1990	0.106966	11	2000	0.253258	19

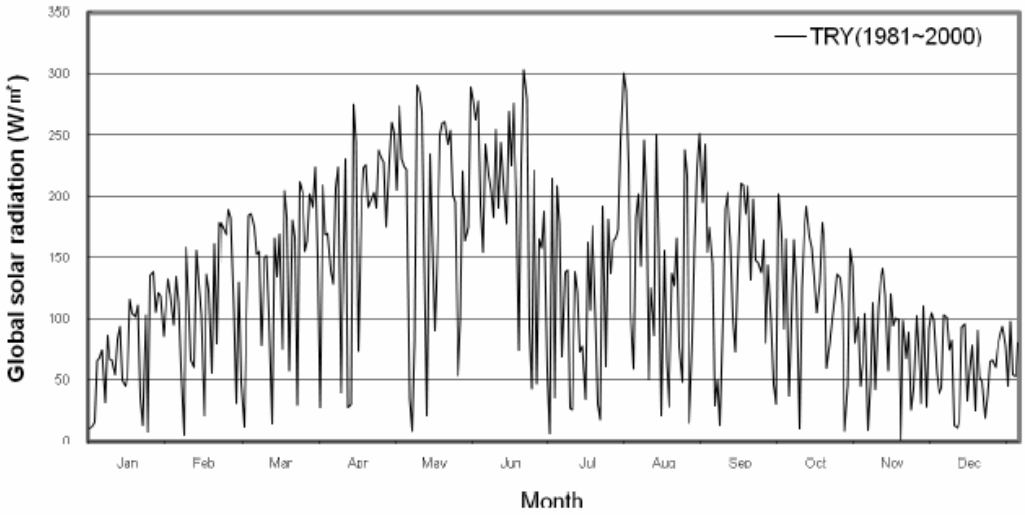
Results and Discussion

CDFs for different January comparisons for Seoul



Results and Discussion

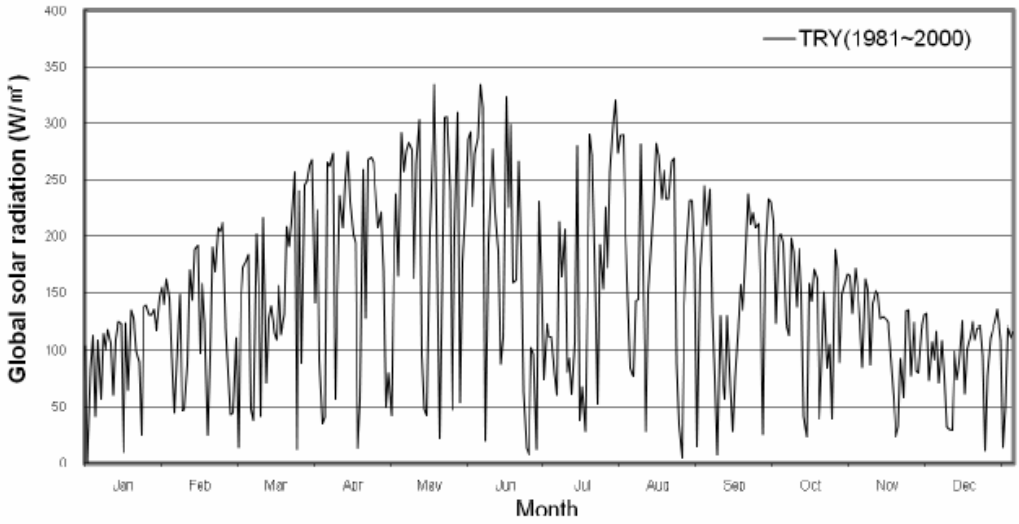
Daily global solar radiation for TRYs of Seoul



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fsmin.	0.0360	0.0314	0.0355	0.0308	0.0152	0.0383	0.0290	0.0173	0.0307	0.0252	0.0367	0.0315
Year	1991	1991	1983	1999	1992	1994	1988	1993	1991	1996	1981	1997

Results and Discussion

Daily global solar radiation for TRYs of Ulsan



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fsmin.	0.0302	0.0429	0.0328	0.0317	0.0262	0.0257	0.0364	0.0400	0.0320	0.0251	0.0410	0.0356
Year	1987	1985	1985	1984	1995	1985	1986	1991	1987	1994	1994	1992

Results and Discussion

- The solar irradiances of Ulsan that is located in the south of Korea and Seoul that is located in the middle of Korea are compared in tables 1 and 2.

Table 1. Top/bottom 2% percentile values of solar irradiance and mean cloud cover for 1981~2000, 2005~2024, 2030~2049, 2080-2099. Values in fills are difference compared to HadCM3 1981~2000(grid box: 127.5, 37.5)

	Ulsan (1981~2000)	Seoul (1981~2000)	HadCM3 (1981~2000)	HadCM3 (2005~2024)	HadCM3 (2030~2049)	HadCM3 (2080~2099)
Summer solar 98%lie value(W/m²)	321.53	288.80	353.18	358.69	351.07	346.21
	-31.65	-64.38		5.51	-2.11	-6.97
Summer solar mean value(W/m²)	174.58	155.05	226.17	225.09	205.68	212.98
	-51.59	-71.12		-1.08	-20.50	-13.19
Summer mean cloud cover	0.64	0.66	0.46	0.47	0.49	0.48
	0.18	0.20		0.01	0.03	0.02
Winter solar 98%lie value(W/m²)	10.78	9.61	22.38	20.22	8.61	20.96
	-12.05	-13.22		-2.61	-14.23	-1.82
Winter solar mean value(W/m²)	104.72	82.34	132.24	130.32	129.58	123.48
	-27.52	-49.90		-1.92	-2.67	-8.76
Winter mean cloud cover	0.35	0.38	0.24	0.23	0.24	0.26
	0.11	0.15		-0.01	0.01	0.03

Results and Discussion

Table 2. Top/bottom 2% percentile values of solar irradiance and mean cloud cover for 1981~2000, 2005~202
2030~2049, 2080-2099. Values in fills are difference compared to HadCM3 1981~2000(grid box: 127.5, 35)

	Ulsan (1981~2000)	Seoul (1981~2000)	HadCM3 (1981~2000)	HadCM3 (2005~2024)	HadCM3 (2030~2049)	HadCM3 (2080~2099)
Summer solar 98%lie value(W/m²)	321.53	288.80	357.25	324.79	341.52	340.67
	-35.71	-68.45		-32.46	-15.72	-16.58
Summer solar mean value(W/m²)	174.58	155.05	184.84	162.06	162.64	155.35
	-10.25	-29.79		-22.78	-22.02	-29.49
Summer mean cloud cover	0.64	0.66	0.70	0.78	0.74	0.79
	-0.06	-0.03		0.08	0.04	0.09
Winter solar 98%lie value(W/m²)	10.78	9.61	15.02	25.54	15.42	14.33
	-4.24	-5.41		10.52	0.40	-0.69
Winter solar mean value(W/m²)	104.72	82.34	127.07	130.61	126.30	125.33
	-22.35	-44.73		3.54	-0.77	-1.75
Winter mean cloud cover	0.35	0.38	0.34	0.31	0.35	0.35
	0.01	0.04		-0.03	0.01	0.01

Results and Discussion

- Figure 1, 2 shows HadCM3 data and Observed data from Seoul, Ulsan considered in this study.

- To simplify the analysis, the average daily solar irradiation for each year were studied for the summer months (June, July, August) and the daily minimum solar irradiation do not follow a distinct trend from year to not follow a distinct trend from year to year, a 10-year sliding average line is plotted through the scatter of the individual annual data.

Results and Discussion

HadCM3 average daily radiation data(127.5, 37.5) & Observed average data from Seoul (Summer & Winter)

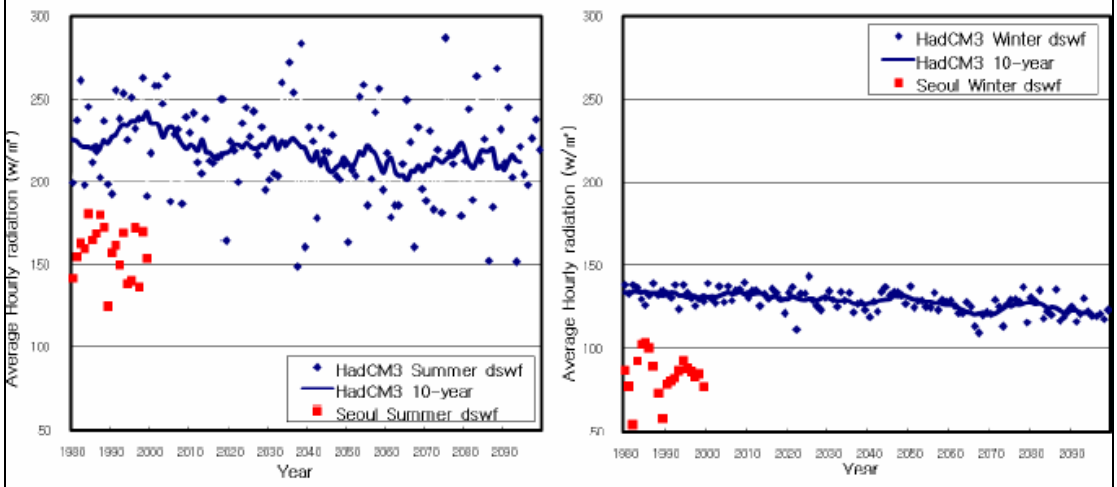


Figure 1. Average daily radiation for summer (June, July and August) and winter (December, January, February) for Seoul (Grid box: 127.5, 37.5)

Results and Discussion

HadCM3 average daily radiation data(127.5, 35) & Observed average data from Ulsan (Summer & Winter)

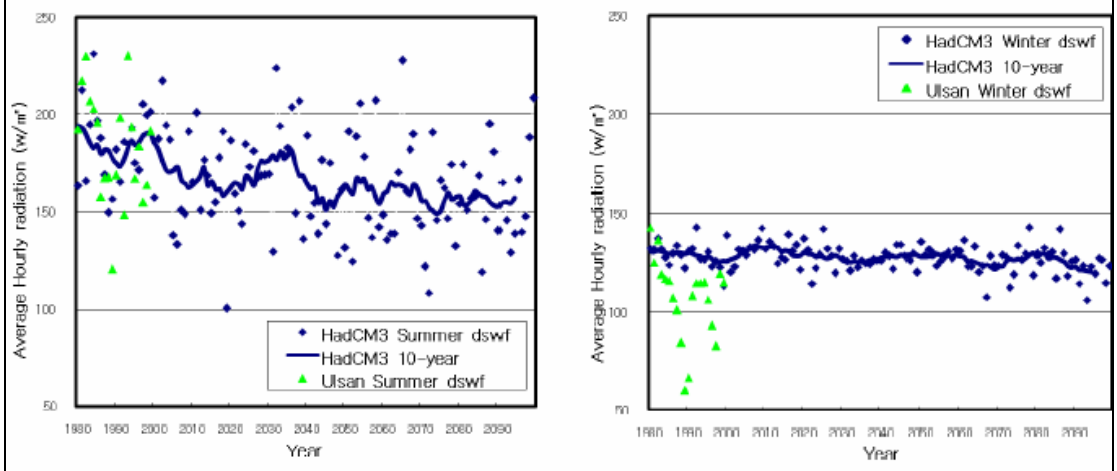


Figure 2. Average daily radiation for summer (June, July and August) and winter (December, January, February) for Ulsan (Grid box: 127.5, 35)

Results and Discussion

HadCM3 average cloud cover data(127.5, 37.5) & Observed average data from Seoul (Summer & Winter)

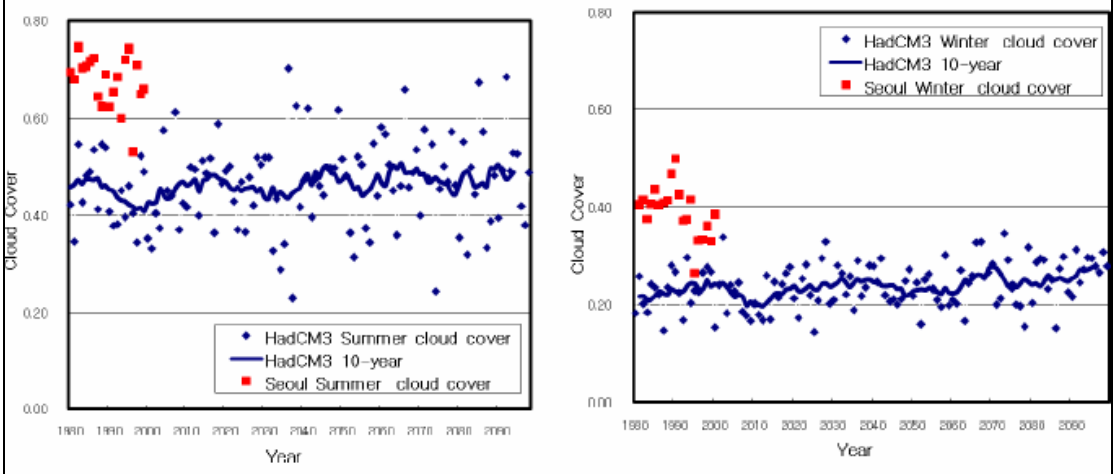


Figure 5. Average daily cloud cover(TCLW) for summer (June, July and August) and winter (December , January, February) for Seoul (Scale of 0 to 1, where 0 is a completely clear sky, 1 is totally overcast)

Results and Discussion

HadCM3 average cloud cover data(127.5, 35) & Observed average data from Ulsan (Summer & Winter)

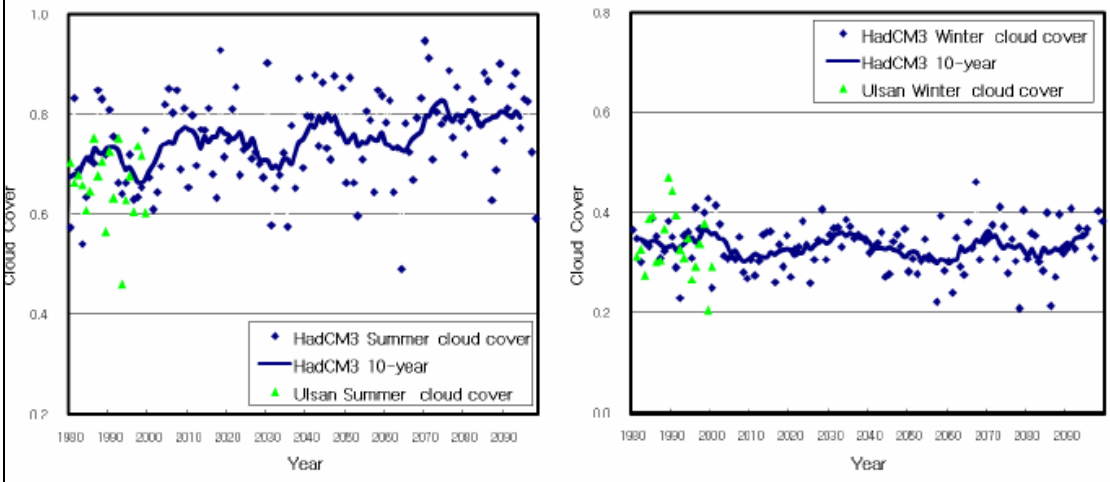


Figure 6. Average daily cloud cover(TCLW) for summer (June, July and August) and winter (December , January, February) for Ulsan (Scale of 0 to 1, where 0 is a completely clear sky, 1 is totally overcast)

Conclusion

- The environmental pollution will cause solar irradiance and cloud cover in the next 100 years, which will lead the continuous decrease in irradiance and increase in cloud cover.

- Also, there are no significant differences between the calculated values for winter. Accordingly, it is closely related to the increase of the cloud cover caused by the pollution in Seoul that is the largest city in Korea.

- It is shown that the maximum 2% and the average solar irradiance of Ulsan in summer are 321.5 W/m2, and 174.58 W/m2, respectively, which are higher than 288.80 W/m2, and 155.05 W/m2 of Seoul.