
Study of Clear Sky Models for Singapore

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Abstract

In this paper, we perform a comparative analysis of several popular clear-sky models, for a tropical region like Singapore. This is important, primarily in the field of solar energy generation and forecasting. We analyze and compare three popular clear-sky models – Bird model [1], Yang model [2] and CAMS McClear model [3]. We validate our results using actual solar irradiance measurements, and conclude the most reliable clear sky model for Singapore.

The total solar irradiance falling on the earth’s atmosphere, in the event of the clear day without any clouds, is referred as the clear-sky solar radiation. It is important, particularly in tropical countries like Singapore, that experiences most of the direct solar irradiance, and is useful for solar energy generation. Several theoretical models have been developed that estimates the clear sky global solar irradiance (GHI). Bird et al. uses results from radiative transfer codes, to estimate the total irradiance, by keeping the various atmospheric factors as constant throughout the year. Recently, Yang et al. proposed an empirical regression model, that is specifically designed for Singapore. Also, the atmosphere service of Copernicus (CAMS) uses the recent measurement results of various aerosol properties and water vapor content, to provide reliable estimates of solar irradiance.

In this paper, we study these models ¹ for a specific location in Singapore (1.34°N, 103.68°E). Figure 1 shows the various models for a sample clear sky day of 7-April-2016, along with the actual solar irradiance measurements, recorded by the weather station at this location. We observe that, for this sample day, both Bird model and Yang model over-estimates the actual solar irradiance values. However, McClear model can better estimate the actual solar irradiance measurements.

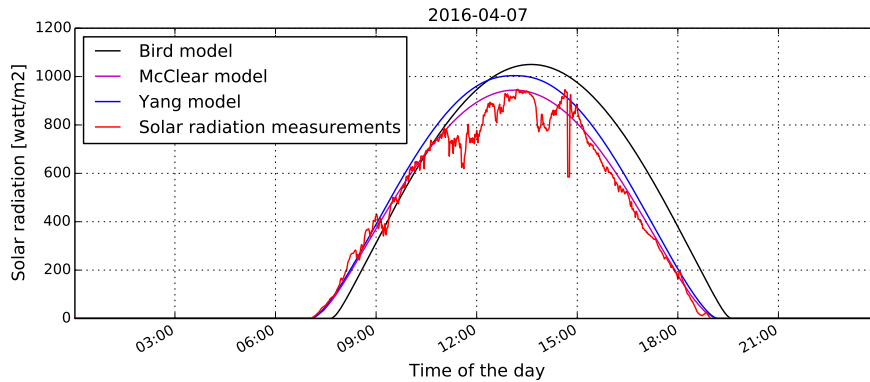


Figure 1: Comparison of various clear sky models for a sample day in Singapore.

In order to provide an objective evaluation of the various models, we compute the Pearson correlation co-efficient and Root Mean Square Error (RMSE) between the actual- and estimated-solar irradiance values. Table 1 shows the results for 7-April-2016. The McClear model has the least RMSE value, and highest correlation value amongst all the models.

	Correlation	RMSE (W/m^2)
Bird model	0.97	114.84
McClear model	0.99	41.04
Yang model	0.99	66.48

Table 1: Evaluation of various clear sky models for the sample day in Singapore

In the extended version of this paper, we will perform our analysis for a larger statistical duration. We will record all the clear sky days in a single year, and estimate the best model amongst all benchmarking methods.

REFERENCES

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¹The source codes of these models will be made available online in the final version.