

**BROAD-BAND SOLAR IRRADIANCE AND PHOTOMETRIC ILLUMINANCE
AT THE TROPICAL STATION IN ILE-IFE,
NIGERIA**

EMMANUEL CHILEKWU OKOGBUE

(M. Sc., M.Phil., Ife)

A THESIS IN THE DEPARTMENT OF PHYSICS
SUBMITTED TO THE FACULTY OF SCIENCE
IN PARTIAL, FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF
DOCTOR OF PHILOSOPHY (Ph. D.),
IN PHYSICS (METEOROLOGY OPTION)
OF
THE OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA

2007



ABSTRACT

The main objectives of this research were to investigate the diurnal variations of the solar radiation fluxes and the associated solar radiation ratios with a view to characterising the sky conditions over Ile-Ife, Nigeria and establishing models for estimating the radiation fluxes at the station.

Hourly solar radiation flux densities (global and diffuse) and ambient temperature measured at the rooftop of the Physics Department Building, Obafemi Awolowo University (OAU), Ile-Ife, Nigeria, between 1992 and 2002 and photometric illuminance measured between 1992 and 1996 were utilized for the study. Additional solar radiation data measured during the Nigerian Micrometeorological Experiments (NIMEX-1, 2 and 3) at OAU during the months of February and March of 2004, 2005 and 2006 were also utilized. The solar radiation ratios (the clearness index, the cloudiness index, and the luminous efficacy) computed from the measured solar fluxes and relevant astronomical relationships were investigated for diurnal and seasonal variations. These ratios (which are sky conditions indicators) were also used to characterize the local sky conditions over Ile-Ife and to develop statistical models for estimating the solar irradiance (global and diffuse) and photometric illuminance at the station.

Very strong diurnal variations in the solar input and solar radiation ratios were observed resulting from the influence of the intervening atmosphere such that on particular days in August and December 1993 only about 45% and 53% respectively, of the total solar radiation arriving at the edge of the atmosphere at local noon actually got to the surface. The local sky conditions at the station were almost devoid of clear skies (clear skies occurred for only about 3.5% of the time). Overcast skies were also very scarce (overcast skies occurred for only about 4.8% of the time). The sky conditions were rather predominantly cloudy (cloudy skies occurred for above 72% of the time) all the

year round. Daylight availability at Ile-Ife in terms of luminous efficacy was as low as 35 lm/W and as high as 115 lm/W and varied seasonally. The probability of having daylight at Ile-Ife with luminous efficacies more than 100 lm/W was about 24% of the time on hourly and 33% of the time on daily bases. Empirical models for estimating diffuse solar radiation and photometric illuminance from the more readily measured global solar radiation were established for Ile-Ife. Models for estimating global solar radiation from the more readily measured ambient temperature were also established for the station. Inter comparison of the models using mean bias error (MBE), root mean square error (RMSE) and t-statistic showed that for any of the models, estimated values were not significantly different from their measured counterparts. The t-values ranged between $t = 0.22$, $P > 0.05$ and $t = 0.88$, $P > 0.05$. The models therefore predicted the measured values accurately.

It was concluded that the local sky conditions over Ile-Ife were predominantly cloudy all the year round and almost devoid of clear skies and overcast skies and that the models predicted the measured values accurately.