*NIWA UV Workshop, Auckland, 15-17 Apr, 2014* (*www.niwa.co.nz/atmosphere/uv-ozone/uv-science-workshops/2014-uv-workshop*)

# A model for estimating diffuse erythemal ultraviolet radiation in the tropics: A case study at Nakhon Pathom, Thailand

S. Buntoung[1,*], P. Choosri[1], K. Chiwpreecha[1], S. Janjai[1], K. Tohsing[1], M. Nunez[2]

1. Department of Physics, Faculty of Science, Silpakorn University, Nakhon Pathom 73000, Thailand
2. School of Geography and Environmental Studies, University of Tasmania, Hobart 7001, Australia

**Abstract.** Global and diffuse erythemal ultraviolet radiation (EUVR) was measured at Nakhon Pathom (13.82 °N, 100.04 °E), Thailand. A one-year period of EUVR from this measurement was used to develop a model for estimating diffuse EUVR. The model expresses the ratio of diffuse EUVR to global EUVR as a function of EUVR clearness index and solar zenith angle. The model gives root mean square error of 13%, when tested against an independent data set.

## Introduction

Erythemal ultraviolet radiation (EUVR) has harmful effects on human health (Zerefos and Bais, 1996; WHO, 1979). EUVR reaching the earth's surface consists of direct EUVR and diffuse EUVR. Diffuse EUVR is caused by the scattering of direct EUVR from clouds, aerosols and air molecules. In the tropics, clouds play an importance role in generating diffuse EUVR, especially during the rainy season. Consequently, contribution of diffuse EUVR in the global EUVR reaching the earth's surface is very significant. As both direct and diffuse EUVR has adverse effects on human health, information on the amount of diffuse EUVR is of importance for avoiding such effects, especially during the rainy season which diffuse EUVR is dominant. However, measurement of diffuse EUVR is scarce. Therefore, the objective of this work is to develop a model for estimating diffuse EUVR based on the simultaneous measurement of diffuse and global EUVR at a tropical site in Nakhon Pathom, Thailand.

## Measurements

A uv-biometer (Solar Light, model 501A) was used to measure global EUVR whereas another uv-biometer (Solar Light, model 501A) equipped with a shade ball on a solar tracker (Kipp&Zonen, model 2AP) was employed to measure diffuse EUVR. The two biometers were installed on the rooftop of the Science Building 1, Silpakorn University located in Nakhon Pathom (13.82 °N, 100.04 °E), Thailand (Figure 1). The voltage signals from these biometers were captured every one second. Then the signals were averaged over the period of 10 minutes. These averaged signals were converted into EUVR dose rates by using the method described by Webb et al. (2006). A two-year period of data (March, 2011-February, 2013) from these measurements was separated into two data sets. The first set (March, 2011-February, 2012) was used to formulate the model while the second set (March, 2012-February, 2013) was employed to validate the model.

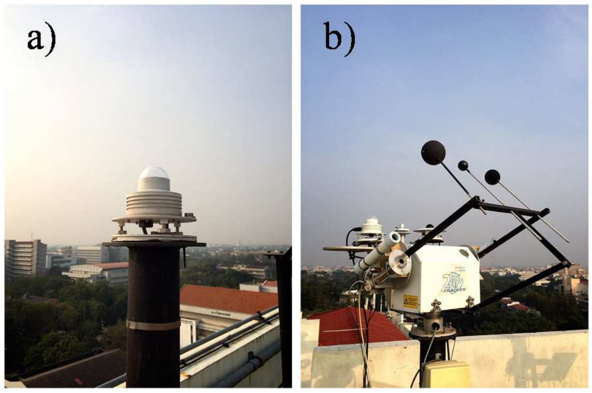


**Figure 1.** The two UV-biometers for measuring a) global EUVR and b) diffuse EUVR at Nakhon Pathom, Thailand.

## Results and discussion

In general, diffuse EUVR depends on the amount and optical properties of clouds, aerosols and air mass. To take these into account, we proposed to use EUVR clearness index ($k_{EUVR}$) and solar zenith angle (z) as predictors of the ratio of diffuse EUVR ($EUVR_D$) and global EUVR ($EUVR_G$) and the proposed model for estimating diffuse EUVR is written as follows:

$$\frac{EUVR_D}{EUVR_G} = a_0 + a_1 k_{EUVR} + a_2 k_{EUVR}^2 + a_3 z + a_4 z^2 \quad (1)$$

where $a_0, a_1, a_2, a_3, a_4$ are empirical constants and $k_{EUVR}$ is defined as the ratio of global EUVR to extraterrestrial EUVR.

To determine the empirical constants, Eq. (1) was fitted by the one-year data set (March, 2011-February, 2012) using the non-linear multi-variable regression analysis (Woodbury, 2002) and the result is shown in Table 1.

**Table 1**. Values of coefficient and t-statistic obtained from the fitting. (R is correlation coefficient)

| Coefficient | Value | t-statistic |
|---|---|---|
| $a_0$ | 1.16232 | 130.7 |
| $a_1$ | -216.96230 | -7.2 |
| $a_2$ | -14.64686 | -15.3 |
| $a_3$ | 0.00002 | 3.4 |
| $a_4$ | -0.00502 | -14.5 |
| R=0.84 | | |

To determine its performance, the model was used to calculate diffuse EUVR at the same site for the period of data: March, 2012-February, 2013, and the result was compared to diffuse EUVR obtained from the measurement (Figure 2).

From Figure 2, it is observed that the comparison between diffuse EUVR calculated from the model and from the measurement is in reasonable agreement with the root mean square error (RMSE) and mean bias error (MBE) of 13% and -3%, respectively. As the model performance was evaluated at the same site where EUVR data were used for developing the model, it is interesting to test performance of this model in other locations in this region. This will be done for further research in this subject of our research group.

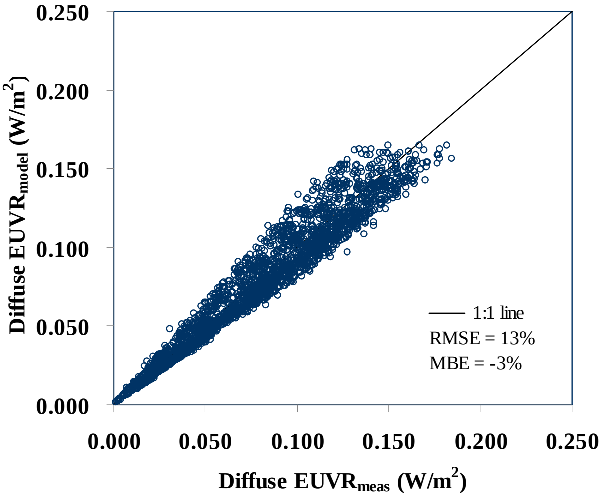


**Figure 2.** The comparison between diffuse EUVR calculated from the model and that from the measurement.

## Conclusion

Global and diffuse EUVR were measured at Nakhon Pathom, Thailand. Based on this measurement, a model for predicting diffuse EUVR was employed. When testing against an independent data set, the model predicts diffuse EUVR with RMSE and MBE of 13% and -3%, respectively.

## References

Webb, A., Grobner, J., Blumthaler, M., 2006. A practical guide to operating broadband instruments measuring erythemally weighted irradiance, 21 pp, WMO SAG UV and Working Group 4 of COST-726 Action "Long Term Changes and Climatology of UV Radiation over Europe".

WHO, 1979. Environmental health criteria for ultraviolet radiation. Geneva.

Woodbury, G. 2002. An introduction to statistics. Duxbury. Australia.

Zerefos, C.S., Bais, A.F., 1997. Solar ultraviolet radiation: modelling, measurements and effects. Proceedings of ASI, Greece, NATO Series I-52.