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Research Paper

Study on solar ultraviolet erythemal dose distribution over Peninsular Malaysia using Ozone Monitoring Instrument

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A B S T R A C T

The discovery of Antarctic hole in early 1980, causes a rise of global interest towards the amount of solar ultraviolet radiation (UV) falling onto the surface of the Earth. The danger that UV radiation brings to the Earth ecosystem makes any information related to UV radiation becomes valuable. Almost all the irradiative energy entering the Earth's atmosphere comes from the sun. The incoming solar radiation covers the entire electromagnetic spectrum from gamma and X-rays, through UV, visible, and infrared radiation to microwaves and radiowaves. For this study, the data are obtained from Ozone Monitoring Instrument (OMI) that onboard AURA satellite. Moreover, the study also focused on analyzing and mapping the distribution trend of UV erythemal daily dose rate over Peninsular Malaysia in 2015. The maximum UV erythemal daily dose appeared in April with its value of 7711.43 J/m^2 while the minimum daily dose was in December recorded at 5518.13 J/m^2. Consequently, April and December also charted to be having the maximum and minimum monthly mean erythemal dose. The study found that there is a strong correlation between spatial and temporal variation of UV erythemal daily dose with monsoon seasons and solar inclination angle in Peninsular Malaysia.

1. Introduction

Solar ultraviolet (UV) radiation is the energy that comes from the sun. UV radiation is more energetic than visible rays because it has shorter wavelength. UV radiation is divided into three spectral bands, UV–A has wavelength range 315–400 nm (McKenzie et al., 1999). UV–A falls completely onto the Earth without any interaction with ozone (O_3). UV–C radiation is completely absorbed by atmospheric oxygen, O_2 and O_3 in the middle and upper atmosphere which then cause disruption of balance in the stratosphere and mesosphere (Chandra and McPeters, 1994). UV–B is absorbed efficiently but not completely by stratospheric O_3; thus, its surface intensity depends on the O_3 layer concentration (Madronich et al., 1998).

UV–B radiation benefits human as it gives positive effects on physiological well–being of human by satisfying Vitamin D's requirement of body. However, UV–B radiation is also the most efficient in inducing mutation in epidermal cell, upregulates gene expression and suppresses immune reaction to antigens. These effects of UV–B radiation have contributed to the development of cancer cell in animal and human (Ichihashi et al., 2003). Furthermore, UV radiation also holds detrimental effects on the balance of the aquatic ecosystem and terrestrial ecosystem (Ballaré et al., 2011).

Malaysia is situated in the equatorial zone and is strongly affected by the Southeast Asia Maritime Continent Monsoon. Malaysia exhibits the distinct characteristics of tropical countries; high temperature and heavy rainfall throughout the year. The climate of Malaysia is affected by two monsoon seasons; Southwest monsoon (SWM) [April–September] and Northeast monsoon (NEM) [October–March]. The sporadic cold surges over period of year and the closed distance to the Inter-Tropical Convergence Zone (ITCZ) during the monsoon transitions (March and October) influenced the wind vector patterns of the equatorial regions of South China Sea and have been strongly associated with the heightened upper–tropospheric outflow and heavy rainfall in the region (Chang et al., 2005; Tangang et al., 2012).

It is very crucial to have instruments that can observe and record the extent and the depth of changes in penetration of UV radiation onto the Earth. Though aircraft-mounted and ground-based tools can make through measurements of parameter values at troposphere, they still are not able to offer precise measure-

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ments on a global scale (Tan et al., 2016). Thus, high spatial resolution satellites with specific specifications are needed to be able to monitor surface UV irradiance trends. Environmental and medical authorities can benefit from the data recorded for predictions of air quality, public health and agronomic productivity (Levelt et al., 2006a).

Previously, lots of researches focus on the solar irradiation and the results of the work shown as solar irradiation maps, especially the yearly mean solar irradiation isoline maps were plotted over tilted surfaces and over vertical surfaces (Bilbao et al., 2003). Furthermore, Mateos et al. (2013) carried out a study on the validation of Ozone Monitoring Instrument (OMI) satellite erythemal daily dose retrievals using ground-based measurements from fourteen stations. Besides, Tanskanen et al. (2007) also carried out a validation of daily OMI estimations at 17 stations and 18 instruments around Europe, Greece, North America, New Zealand, and southern Argentina. Thus, this shows that UV radiation data derived from OMI instrument have been widely used and validated through comparison with in-situ measurements.

2. Study area

Peninsular Malaysia is in Southeast Asia within the latitudes of 1–7° N and the longitudes of 99–105° E (south of Thailand, north of Singapore, and east of Sumatra). Peninsular Malaysia has an area of approximately 131,587 km^2 (Fig. 1) and an estimated population of 23 million.

Peninsular Malaysia enjoys a humid tropical climate throughout the year; the weather is warm and humid, and the temperature ranges from 20 °C to 32 °C (Omar, 2009). Mountainous topography and complex land-sea interactions significantly influence the tropical climate. Intra-seasonal and inter-decadal fluctuations, such as the El Niño Southern Oscillation, the Indian Ocean Dipole, and the Madden Julian Oscillation, significantly influence Malaysia's interannual climate variability. April to May and July to August are the months with the highest average temperatures, and the lowest average temperatures occur from November to January.

In Peninsular Malaysia, the average monthly humidity falls between 70% and 90%, varying by location and month. Peninsular

Fig. 1. Geographical features of the study area. (Source: http://www.mapofworld.com/lat_long/malaysia-lat-long.html).