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Distributions of sky luminance and radiance of North Bangkok under standard distributions

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Abstract

In the tropics, the sky is luminous and variable. Distribution of luminance over the sky dome is non-uniform and varies widely and dynamically with weather condition. The high luminosity offers good potential for daylighting, but an understanding of the luminance distribution of tropical sky would help advance the movement for daylighting. This paper reports results of a characterization of sky luminance and radiance under the standard sky luminance patterns proposed by Kittler using measurements from a station located north of Bangkok. In accordance to the standard sky luminance classification, the sky patterns of north Bangkok mostly fall into clear and intermediate types. During cooler months, the sky is clear for over 60% of the time. In the midst of the rainy season, the sky falls into the intermediate category for over 40% of the time. The high incidence of clear sky on this classification differs from earlier results that use sky ratio and Perez's clearness indices in the classification of sky condition.

Keywords: Sky luminance distribution; Indicatrix function; Gradation function; Root mean square difference; Mean bias difference

1. Introduction

Daylighting or the planned use of natural daylight in building interior has been recognized to possess good potential for application in tropical regions since 1960s [1].

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Daylighting using skylight (diffuse light from the sky, excluding sunlight) through window has been shown to lead to savings of electrical lighting energy of up to 50% [2,3].

Modern tools used for computation of the amount of daylight in building interior require precise spatial distribution of sky luminance. Daylight from certain part of sky enters a window or aperture oriented in a given direction more significantly than that from other part of the sky due to the high non-uniformity of its distribution. Uniform sky luminance model or even clear sky and overcast sky models are no longer adequate. As pointed out by Kittler [4], with the use of modern computational tool, simplification of sky luminance model is no longer necessary. Complex computations can be performed in the background while useful results can be obtained and presented without requiring the users to learn of the complexity involved.

Since the launch of International Daylight Measurement Program (IDMP) by the International Commission on Illumination (CIE, Commission Internationale de l'Eclairage) in 1991, measurement of daylight illuminance has been undertaken and reported from various parts of the world [5–14]. Distribution of luminance of the sky has also been recorded to obtain more information on characteristics of daylight. A few stations with equipment that can measure sky luminance have been erected in the subtropical region of Hong Kong. Some stations are closer to the tropics such as those in Thailand and Singapore.

Sky luminance distribution has been studied from measurements taken in high latitude locations (Europe, USA, and Japan). A number of luminance distribution models developed from measurements and some of them have been adopted by the CIE as standard sky models, [15–23]. Kittler [4], in 1997, proposed a methodology to characterize sky luminance distribution and recommended that a set of 15 standard sky luminance distributions (SSLD) be adopted. The standard set encompasses the existing CIE SSLD models for overcast sky, polluted (turbid) clear sky, and unpolluted clear sky. The standard set is hypothesized to encompass all possible patterns of sky distributions that may occur anywhere. It has been recommended that measurements of sky luminance of a given location be evaluated against the SSLD to determine the statistical distribution of local sky luminance distribution in terms of SSLD. This paper presents results along such line. We first identify one of the 15 standard sky distribution model a sky luminance scan from our records best fit into. We also put the radiance values from the same scan into a parallel slot. In this way, we eventually obtain statistical distribution of the luminance of our sky in terms of percentage occurrences under standard sky distributions (SSLD). We next use the luminance values of the sky scans under each category to find a luminance distribution that best fits that set. The same procedure is taken for radiance measurements. The values of the model parameters obtained from luminance measurements are then compared to those of the standard sky corresponding to the given category. The derived luminance and radiance models are then evaluated against measurement values.

2. Measurement and recording of sky luminance and radiance distributions for North Bangkok

Solar radiation measurement has been taken using equipment operated from the roof of a two-storied building in the campus of the Asian Institute of Technology (AIT), located at latitude 14.08°N and longitude 100.62°E in a mix of suburban area and open space, 42 km north of Bangkok. A set of illuminance and luminance measuring equipment, including a