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A simple model for the derivation of illuminance values from global solar radiation data

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Abstract

This paper presents a new simple luminous efficacy model for global horizontal irradiance. The objective is to derive values of outdoor global horizontal illuminance data from typical local weather station data including global horizontal irradiance and Humidity Ratio of outdoor air. The proposed luminous efficacy model incorporates, as the main influencing variable, the Clearness Factor, which is an original derivative from the Clearness Index. Two further variables are included in the model formulation. These are the Humidity Ratio and the solar altitude. Moreover, the model includes a location-dependent variable, which may be derived from the latitude information. The paper includes the result of the statistical analysis of the relationship between the model predictions and the measured data. The results of this analysis display a good agreement between predictions and measurements.

Keywords

daylight,
irradiance,
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1 Introduction

To perform detailed design analyses and evaluation pertaining to daylight conditions in architectural spaces, appropriate models of sky luminance distribution are needed. In the past, various sky luminance distribution models have been developed. However, such models typically require global and diffuse illuminance data for the relevant location. But measured data on global and—especially—diffuse external illuminance are generally not available for most locations. Hence, methods are needed that facilitate the derivation of illuminance and luminance data from the more widely available irradiance and radiance data via reliable luminance efficacy models. Luminous efficacy denotes the ratio of illuminance to irradiance.

Several authors have suggested models to derive luminous efficacy for different sky conditions. Littlefair (1988) and Aydinli and Krockman (1983) presented polynomial relations of different degrees using solar altitude as the only independent input variable for beam luminous efficacy. Another model, which also uses solar altitude as independent variable, was proposed by Robledo and Soler (2001). Littlefair (1988) established diffuse luminous efficacy as an interpolation between overcast and clear sky using sky clearness as an indicator. Using Littlerfair's model, Chung (1992) and Robledo and Soler (2001) developed local luminous efficacy models (based on data from Hong Kong and Madrid, respectively) for overcast and intermediate skies. Perez et al. (1990) developed a luminous efficacy model for all sky types as a function of the solar zenith angle (Z), atmospheric precipitable water content (W) and the sky brightness index (Δ). The coefficients of these variables were specified as a function of sky clearness ranges. Muneer and Kinghorn (1997) derived global luminous efficacy as a polynomial model for all sky types in which the clearness index (k_t) is the only independent variable. Clearness index is defined as the ratio of global horizontal irradiance (I_g) to extraterrestrial irradiance (I_e). Ruiz et al. (2001) developed a different

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