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Solar radiation estimate differences between traditional and advanced view factor analysis methods

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The human body exchanges energy with both the atmosphere and surrounding solid environment. Radiation exchange is one of the most effective climatic influences on human thermal exchange.

Traditional methods for estimating human radiation exchange in three-dimensional (3D) urban environments divide the sky hemisphere into two view factors: open sky and vertical obstructions (buildings and trees). However, view factors of sunny/shaded isothermal urban surfaces should be analyzed separately and vertical vegetation (tree) view factors should be separated from those of buildings. These two effects, vegetation and shadows, were included in an advanced view factor analysis method.

This study compares the traditional view factor analysis method for estimating radiation exchange and the advanced one which includes vegetation and shadow effects. Study sites were three locations in downtown Nanaimo, B.C., Canada (sky view factors: 0.35-0.43) and one location in a small park at Changwon, Republic of Korea (sky view factor: 0.79). Radiation data were measured at three times (morning, noon and afternoon) on Aug. 5, 2008 and July 26, 2009 in Nanaimo and from 11:30 to 17:00 on June 11, 2009 in Changwon. The traditional method adopted normal building, 0.3, and ground, 0.15, surface albedoes. The advanced method used the same building and ground surface albedoes for sunny surfaces and 0.22 for the sunny vertical vegetation surface albedo. Different albedoes were used for shaded surfaces: 0.21, 0.14 and 0.13 for shaded building, vegetation and ground surfaces, respectively. To calculate incident radiation on vertical building and horizontal ground surfaces, the traditional method multiplied normal incidence direct beam solar irradiance by cos β for building surfaces and by sin β for the ground surface. β is solar altitude (°). The advanced method used the same method for the ground surface but included both solar azimuth and solar altitude functions for each individual building surface.

Incoming solar irradiance from the sky hemisphere (K↓) estimated by the advanced method was 70.6±25.9 Wm-2 lower at the sunny locations in Nanaimo and 21.7±9.9 Wm-2 lower in Changwon than that estimated by the traditional method. Solar radiation reflected from the ground hemisphere (K↑) was, also, 28.6±18.3 lower at Nanaimo and 6.8±2.1 lower at Changwon. At the shaded locations in Nanaimo, the differences between the two methods were much less than those at the sunny locations: 9.1±9.9 in K↓ and 9.8±14.3 in K↑.

When the results of the two methods were compared with the measured radiation data, the advanced method's results were closer to the measured ones at the sunny locations than those of the traditional method. The advanced method was more accurate in Nanaimo's narrow urban canyons than at the more open Changwon site. At the shaded locations, both methods gave good estimates of measured radiation.

The advanced view factor analysis method which includes vegetation and shadow effects should improve radiation exchange estimates for human thermal sensation (comfort) analysis in complicated 3D urban environments.