Influence of instantaneous measured data on evaluation interval of daylighting

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Abstract. Daylight varies during daytime and it is an important health aspect of indoor visual environmental quality. Measurements of daylighting are very complicated in natural conditions, therefore processing and evaluation of measured date requires special care. The instantaneous illuminances in one room and outside in Bratislava with 5 - second time step were measured by two illuminance meters with data loggers. The first illuminance meter registered indoor illuminance and was placed on the level of the working plane inside the room in its centre. The second illuminance meter with an unscreened sensor was placed on the roof and measured exterior global horizontal illuminance. Daily illuminance courses derived from 5 sec instantaneous data and 1 min and 1 hour averages were inspected and evaluated. This paper presents results of evaluations of real measurements and the discussion focus on the influence of evaluation interval on the accuracy of daily illuminance courses.

Introduction

Daylight changes are usually perceptible in every moment during a day, therefore daylight measurements of instantaneous illuminances and their evaluations are very realistic and important for indoor climate simulations. Date describing daylight climate are measured and recorded in CIE IDMP - stations. Within this program at 48 stations world-wide regular and high quality daylight and solar radiation measurements are performed. At stations can have operate measuring instruments using various sampling and recording intervals. The sampling interval indicates how often is scanned the signal and outputs from sensors. The recording interval indicates how often are written the output data on the disk. [1] Therefore either instantaneous measured data or average data for a defined interval can be collected and reported at the stations. In this paper the measured instantaneous data are compared with 1min and 1 hour averages. Presented study describes influences of sampling interval on the quality of evaluated data and shows more real daylighting daily changes demonstrated in the shorter 5 sec sampling interval.

Methodology

Illuminance was measured in situ using two illuminance meters Extech HD 450 equipped by data loggers. The first illuminance meter was placed in the room of Academy hostel in Bratislava. The room is located on the 5th floor, it has a L shape in plan, one window and a door to loggia with a south-west orientation. The sensor of this illuminance meter was situated in the centre of the room – see Fig. 1. The second illuminance meter was placed on the roof of the Institute of Construction and Architecture, Slovak Academy of Sciences (ICA SAS), where the CIE IDMP (International Daylight Measurement Programme) station is situated. During measurements on 17th July 2013 morning was a clear summer day and during cloudy afternoon several moving clouds randomly shaded sun disk. The 5 sec sampling interval was adjusted in both illuminance meters. From obtained data were calculated 1 min and 1 hour averages and found maxima which were compared with 5 sec data and evaluated differences between maximum values.

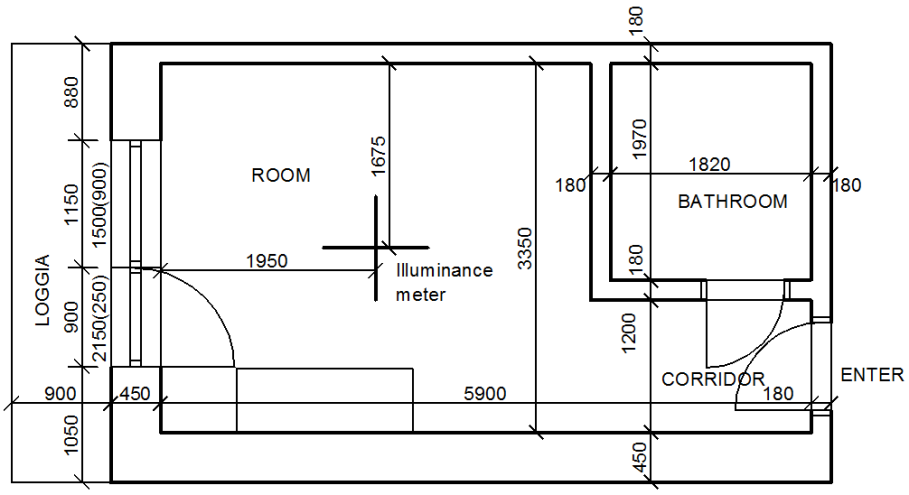


Figure 1 – Plan of the room with position of illuminance meter sensor

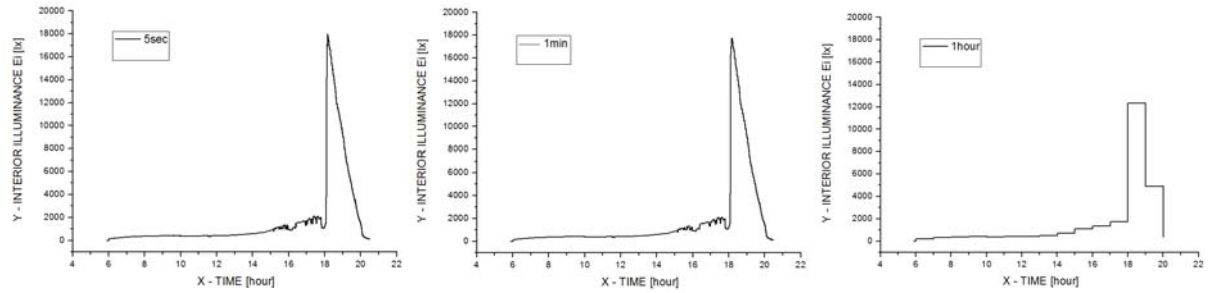
Results

Results of this study represents influence of evaluation data interval on the fluency and illuminance levels in daily courses, Fig. 2 and Fig. 3. The interior illuminances measured in the test room are documented in Fig. 2A while exterior illuminances are plotted in Fig. 3A. Values of interior illuminance is continualy rising from morning up to 3:00 p.m. and then up to 6:00 p. m. it is influenced by clouds. Windows in tested room are North-West orientated, moreover they are shaded by 0.9 m deep loggia. Therefore lover indoor illuminances resulting from skylight are registered during revailing day time, as is shown in Fig. 2B and Fig. 2C. After 6:00 p.m. indoor illuminance is rapidly rising because direct sun rays strike the sensor of illuminance meter.
Maximum values of interior illuminance E_i and exterior illuminance E_e during this summer clear day for sampling intervals of 5 sec (taken as instantaneous data), 1min average data and 1 hour average data are documented in Table 1. The ratio of coincidence between maximal value of illuminance max E_i – 5 sec and 1 min and 1 hour can be described by coefficient k in % and calculated after equation:

$$k = \frac{\max E_i}{\max E_{i,5\text{sec}}} \times 100 \quad [\%] \qquad (1)$$

where max E_i – maximum found out indoor illuminance in lx.

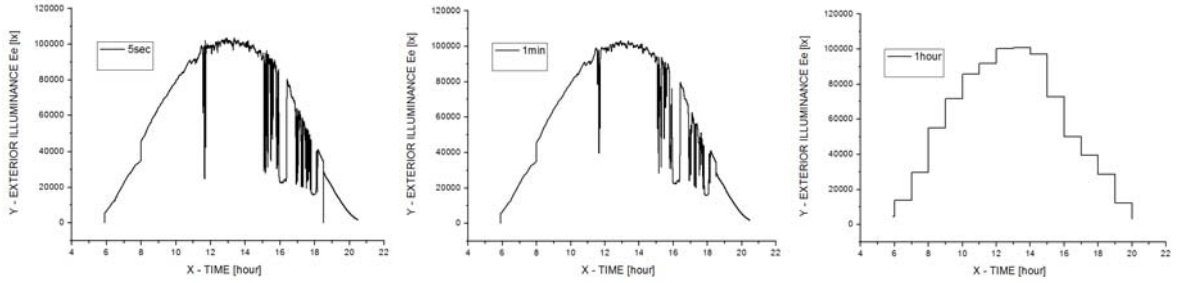
The ratio of coincidence k = 98,6% between maximal value of 5 sec sampling data and 1 min data was found. If 1 hour average data were compared with 5 sec instantaneous data this ratio is dropping to 68,5%, which indicates very different shape of daily illuminance course. Reason for changes of k – ration can be found in averaging data processing. There is opposite dependence between length of evaluation interval and sampling interval. If sampling interval is short and evaluation data interval is short, the k – ratio is high. If sampling interval is short and evaluation data interval is long, the k – ratio is lover due to smoothing of extremes in database.



A. B. C.

Figure 2. Daily interior illuminance courses.
A. Instantaneous 5 sec data, B. 1 min averages, C. 1 hour averages.

The measured exterior illuminances during this July day are documented in Fig. 3 in the same structure as in Fig. 2. Data from morning time are continually changing typical for a clear day, around noon are influenced by veiling clouds and in the afternoon by cumulus clouds. Differences between 5 sec sampling data and 1 min averages data are minimal, but using 1 hour average data it can be introduced substantial errors and results can not correspond to real illuminance conditions.



A. B. C.

Figure 3. Daily exterior illuminance courses.
A. Instantaneous 5 sec data, B. 1 min averages, C. 1 hour averages

Table 1. Maximum values of interior and exterior illuminance

Illuminance	Max. 5 sec		Max. 1 min			Max. 1 hour		
	Value [lx]	Time [hour]	Value [lx]	Time [hour]	*k* [%]	Value [lx]	Time [hour]	*k* [%]
Interior	18012	18:09:31	17755	18:09:30	98,6	12344	18:30:00	68,5
Exterior	103574	12:56:18	103070	12:55:30	99,5	100741	13:30:00	97,3

Summary

This study focuses on discussion about influence of different evaluation data interval on the shape of daily illuminance courses. If instantaneous data recorded in 5 sec interval are used, the daily courses are fluent with original and real measured values. If these data are averaged in 1 min and 1 hour intervals, extremes are smooth, Daily illuminance courses plotted from such data are discrete for short evaluation interval (1 min) and stepped for longer interval (1 hour). Results show, that differences between 5 sec and 1 min data are minimal and therefore recordings of 1 min data are quite representative. For this reason instantaneous or averaged 1 min illuminance date could be used in simulations of dynamic daylighting. Moreover, these 1 min data can describe illuminance courses and changes in any sequence time and for quantifying visual requirements the 1 min database seems

to be optimal. As is documented above, the sequences derived from average 1 hour data can result substantial errors due to relevant differences between real and calculated maximal values and data smoothing and do not satisfactory characterize fluent changes of natural daylight illuminance.

Acknowledgement.

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