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Research Article

Validation of Envi-met Software Using Measured and Predicted Air Temperatures in the Courtyard of Chinese Shophouse Malacca.

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A b s t r a c t

In recent times sustainability design has received a rapid attention, courtyard as one often refers to a microclimate modifier, played an important role in the concept of sustainability. However, studies show that there are various ways to check the performance of courtyard, such ways include field measurement and simulations. This is to enhance the viability of the courtyard design. Chinese shophouse is one of practical examples of courtyard in this context. Generally, the inclusion of courtyard in a building fabric improve the microclimate, for the study of the Chinese shophouse reaches an acceptable level, a thorough validation of the software is crucial. This study intends to validate the envi-met software using the measured and predicted air temperature in a courtyard of Chinese shophouse in Malacca for further analysis. The measured and simulated air temperature of the courtyard of Chinese shophouse is analysed using the statistical method. Results indicate that the measured air temperature found to be in good agreement (d = 0.8) with the simulated air temperature. The performance of the simulator (envi-met software) is highly satisfactory. This method of validation can also extended to other simulation software that uses the outdoor environment.

1. Introduction

Sustainability design is a subject that has desired be explored in the context of the contemporary condition in the actualization of the perception of sustainability(De Chernatony, et al. 2000). For a design to be sustainable, the building must have completely the basics. In this situation, the courtyard is considered as a sustainable design strategy because of its passive nature(Canton, et al. 2014),(Soflaee and Shokouhian, 2005), The studies on courtyard has acknowledged a quick attention and apprehension because of its

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passive nature, however, studies on the courtyard are inadequate in hot humid climate. Courtyard as a microclimate modifier, space inside a building that exposed to the sky is significant in the framework of sustainability. Investigation on courtyard has diverse dimension and methodology. The common amongst is to resolve the problem of ventilation and lighting, however, studies show that courtyard includes geometrical dimensions, thermal quantity and simulations, this depends on the nature of the study. In addition, studies indicate that simulation studies are the most recurrent used method of investigation with courtyard, this is because of its consistency, fortification, easy to use and analysis of various formats of design options (Al-Masri and Abu-Hijleh, 2012),(Berkovic, et al. 2012). In contemporary times simulations model presentation has become issue that most scholars are having attention most particularly the 3-dimensional numerical simulations, however, the 3-dimensional simulations are of benefit because of its time and cost compared to conducting field measurement, in addition, it's lower the application of physics modelling that accomplishes into various variables that upset each other. The hypothesis of environmental enactment that is atypical to the urban environment and improves outdoor microclimate could enhance if the 3-dimensional simulation is applied.

Apparently, from the perspective of this study envi-met simulation software carefully chosen. This is because of its availability and consistently, the software applied in resolving the significance of the design on the environmental variables and the microclimate in this case Air temperature is important. (Chen and Ng, 2012),(Yang, et al. 2012). However, input variables are significant and most are made obtainable besides, the presentation of the simulator will not be of real situation (Salata, et al. 2016). Envi-met software, a prognostic model based on the basics values of fluid dynamics and thermodynamics. It is a 3-dimensional non-hydro-static model for the simulation of surface-plant-air interaction and evaluates the interaction between building surface and plants.

The model calculations include the following: short and longwave radiation in consonance to the shading reflection and radiation from building and vegetation. Transpiration into the air in reference to a full simulation of all plants physical elements. Surface and wall temperature for every ground point and wall. Water and heat exchange inside the soil framework. Assessment of biometeorology variables as mean radiant temperature or Fangers perceptive mean vote value. Scattering of inert gases and particles including sedimentation of particles at leaf's and surfaces. The exhibiting program has four interfaces: the first is the altering the input of arranged drawings design of the area, in this way, one needs to produce baseline info to create herself/himself in Envi-met own cartographic format. This stage can be very unpredictable relying upon the ecological area that worked. The high-resolution part of the program permits the user to go into better points of interest in smaller scales (0.5) or and to be coarser (less nitty gritty) in lower scales (e.g. 10m in an area investigation of 1km by 1km). The project encompasses of modules of working zones, for example, 130 by 130 most extreme, so theoretically one can go to an area investigation of around 1300 by

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1300. The second interface is the setup editor where databases for soil sort, humidity, temperature, temporal information, and so forth entered. The third one is the modelling zone, where extra parameters are available and modelling process happen. The yield can be interpreted and visualise in LEONARDO. It is likewise conceivable to alter the information to another system since the project structure is open. The used of Envi-met as a software cannot be over-emphasized, however, many researchers worked with the software and obtain positive results.

Validation of the Envi-met model has become relevant and necessary in order to configure the performance of the software. Many scholars worked on the validation of the Envi-met software such as; (Salata *et al.*, 2016),(Ghaffarianhoseini, et al. 2015),(Ahmed *et al.*, 2015). However, well laid down evaluation method, as well as standard, is lacking. Study opined that model evaluation should be accompanied using statically analysis by comparing the measured(O) model output in agreement with the predicted(P) data and should have a level of confidence(Sivacoumar and Thanasekaran, 1999)

The use of r and r^2 as used frequently for correlation has been deliberated extensively. Statistical significance of such values is unsuitable specifically when used in comparing predicted (P) and measured (O) variables. However, Wilmott, suggested that root mean square error, RMSE, or mean absolute error, MAE, systematic and unsystematic root mean square error and index of agreement, d, are important(Willmott, 1982). Yahia and Johansson, demonstrates the importance of root mean square error, RMSE, (systematic and unsystematic) and index of agreement, d, for predicting model performance(Yahia and Johansson, 2014). However, Nash and Sutcliffe, advocated another coefficient, E, which is dimensionless, variables that compare models. This coefficient is a better goodness-of-fit model compares to R^2(Nash and Sutcliffe, 1970) Daren and Smith affirmed the use of the following as indicators: E the nash-surclife coefficient of efficiency, d-degree of the agreement, RMSE, root mean square error (systematic and unsystematic) and MAE- mean absolute error(Daren Harmel and Smith, 2007).

The purpose of this study is to validate the Envi-met software by using the measured and predicted air temperatures in a courtyard of a Chinese shophouse in Malacca.

2. Research methodology

The method carried out in this study divided into two, namely field measurement and simulation. The objective of the study is to validate the envi-met software. The measurement conducted in a single story Chinese shophouse from 15/10/2014 to 22/10/2014. The shophouse is located in the central part of the heritage zone in Malacca, Malaysia (2.2^0W, and 102.2^0 E) as shown in figure 1. The courtyard selected based on the historic heritage and peculiar nature of that shophouse. It has a deep courtyard built between 1600 and 1800, with the features of Dutch Architecture. The shophouse as a building has three courtyards, CY1, CY2, and CY3. The shophouse is located at 85, Jalan Tun Tan Cheng Lock. In addition, opened to the street for commercial use. The hottest day 16/10/2014 was selected to be as parameters for the simulation.

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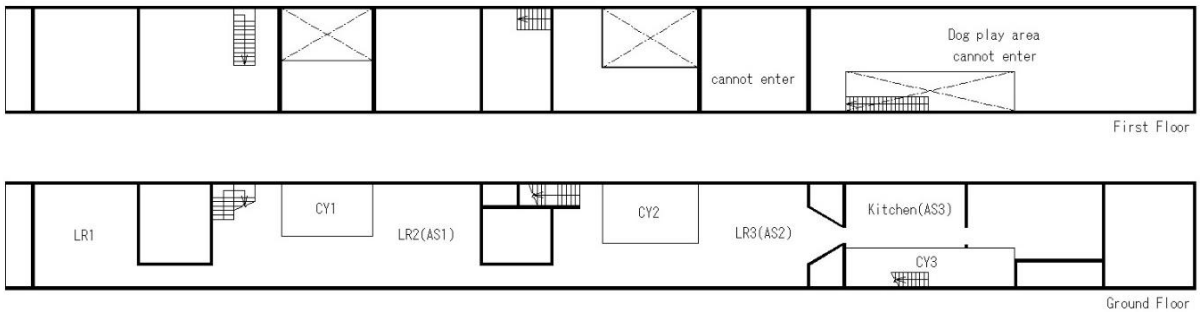

The second part of this study is the validation process involving the simulation. Figure 2 and 3 shows the envi-met parameters as specified in the configurations.

Fig. 1: (a) Floor plans of case study Chinese shophouse 1 and (b) views of the three courtyards

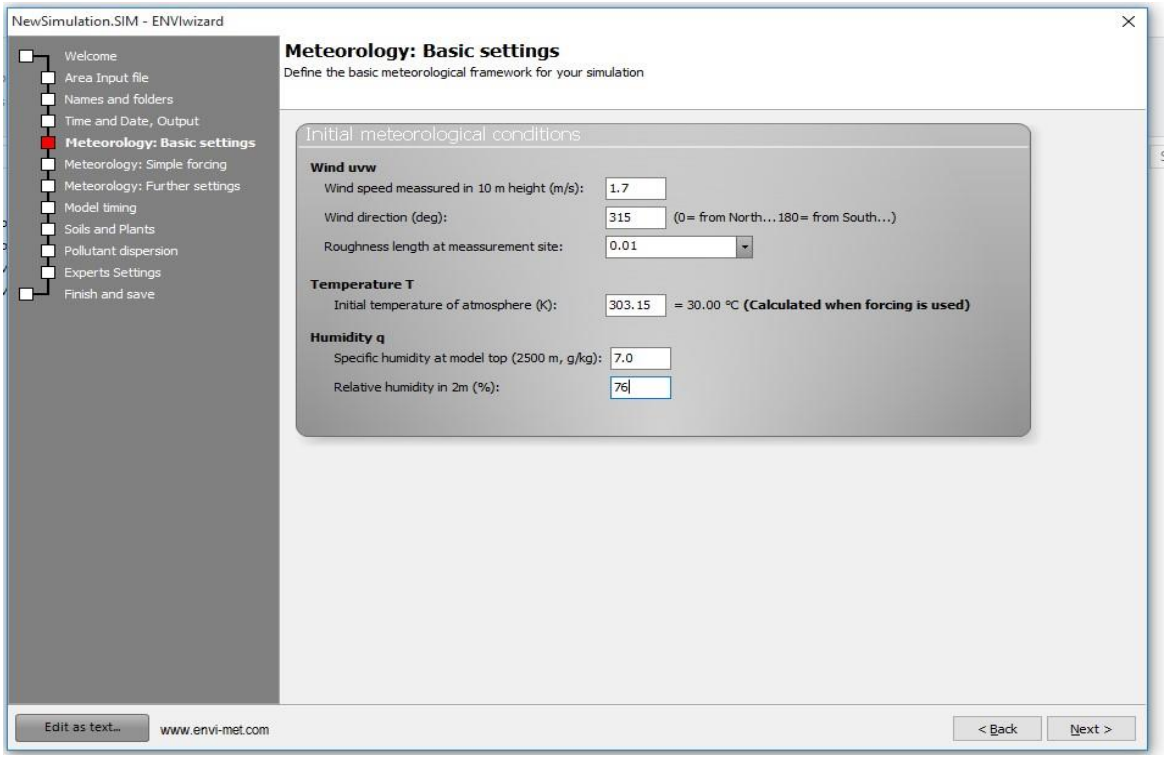

Figure 2: Showing the configuration module of the Envi-met software

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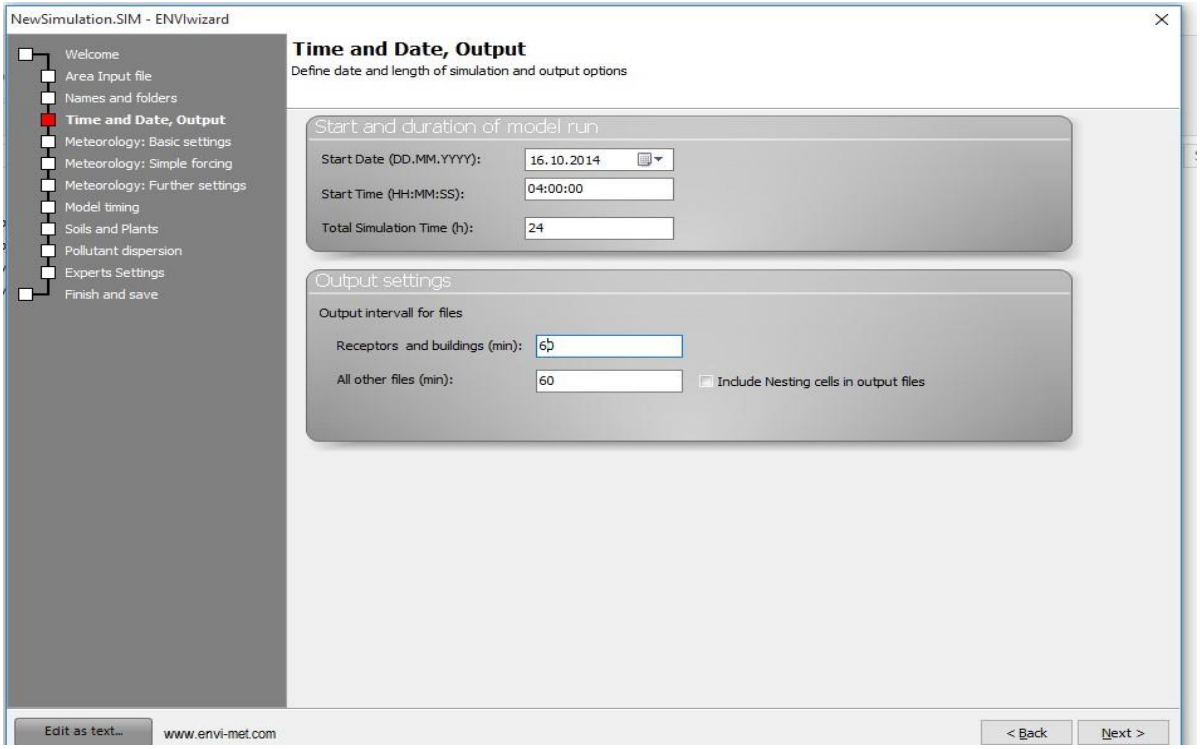

Figure 3: Showing the Configuration Module of the Envi-met Software

3. Results and Discussion

The purpose of this study is to validate the Envi-met software using measured and predicted air temperatures in a courtyard of a shophouse in Malacca, and the objective of the study is to check the performance efficiency of the software, using statistical analysis. Figure 4 shows the graphical representation of the sequential variables measured. Air temperature and relative humidity measured at the Centre of the courtyard at a height of 1.5 m above the ground (CY1). These measured took seven days. The hottest day (16/10/2014) used as the variables for the simulation validation.

Meanwhile, a random test (input data) used to actualize an accurate boundary for the measured and the predicted air temperature as shown in Table 1. Air temperature is a significant weather factor used to formalise the functioning of the models in most published articles.

Seven statistical measurements used to predict the functioning of the model used for the measured data (O), and the predicted data (P). these statistical variable measured are the coefficient of determination, R^2, mean bias error, MAE, root mean square error, RMSE, systematic root mean square error, RMSEs, unsystematic root mean square error, RMSEu, magnitude and the average relative error of agreement, d, and the nash-surclife coefficient of efficiency. Colum 3 is the best variable that fits most in the statistical analysis.

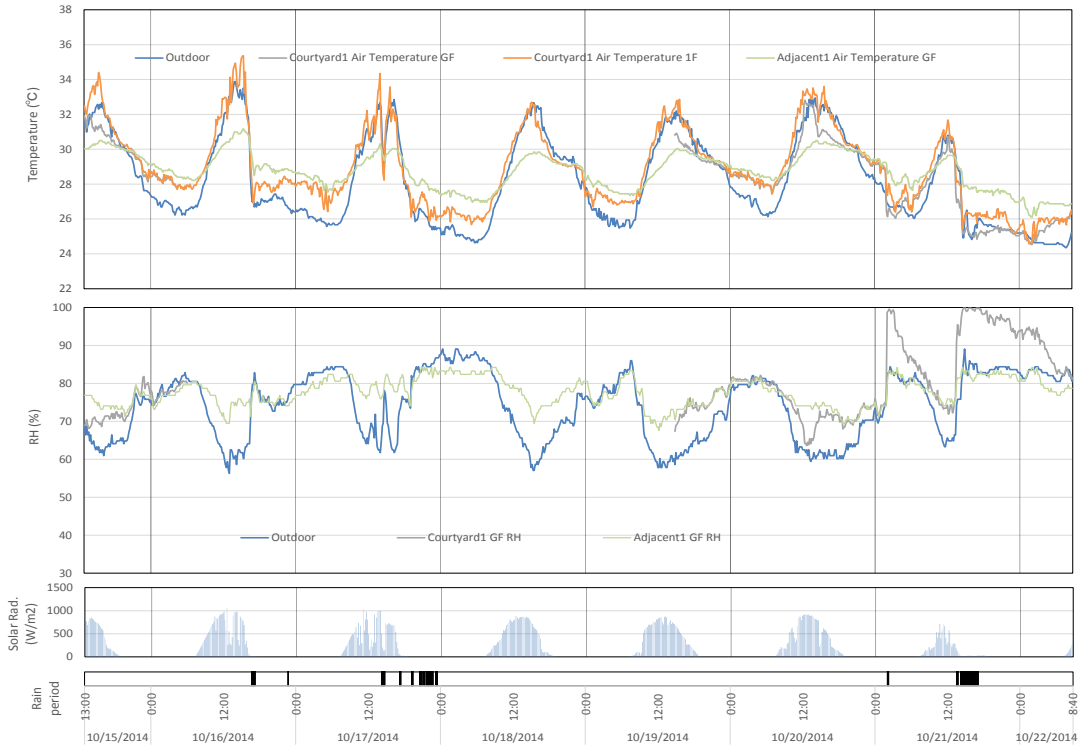

Fig. 4 Sequential variations in shophouse 1 (a) air temperature and (b) relative humidity with the corresponding outdoor conditions

Table 1: Calculated Variables from the Statistical Analysis

SN	Item	Symbol	1	2	**3**	4	5
1	Mean Absolute Error	MAE	0.8	0.8	**0.8**	0.8	0.8
2	Mean Bias Error	MBE	1.0	1.0	**1.0**	0.8	1.0
3	Root Mean Square Error	RMSE	3.0	3.0	**3.2**	2.9	3.2
4	Root Mean Square Error (unsystematic)	RMSEu	2.67	2.78	**2.8**	2.8	2.8
5	Root Mean Square Error (systematic)	RMSEs	1.69	1.46	**1.5**	1.52	1.46
6	Degree of Agreement	d	0.31	0.58	**0.8**	0.4	0.58
7	Nash	£	0.5	0.5	**0.5**	0.5	0.5

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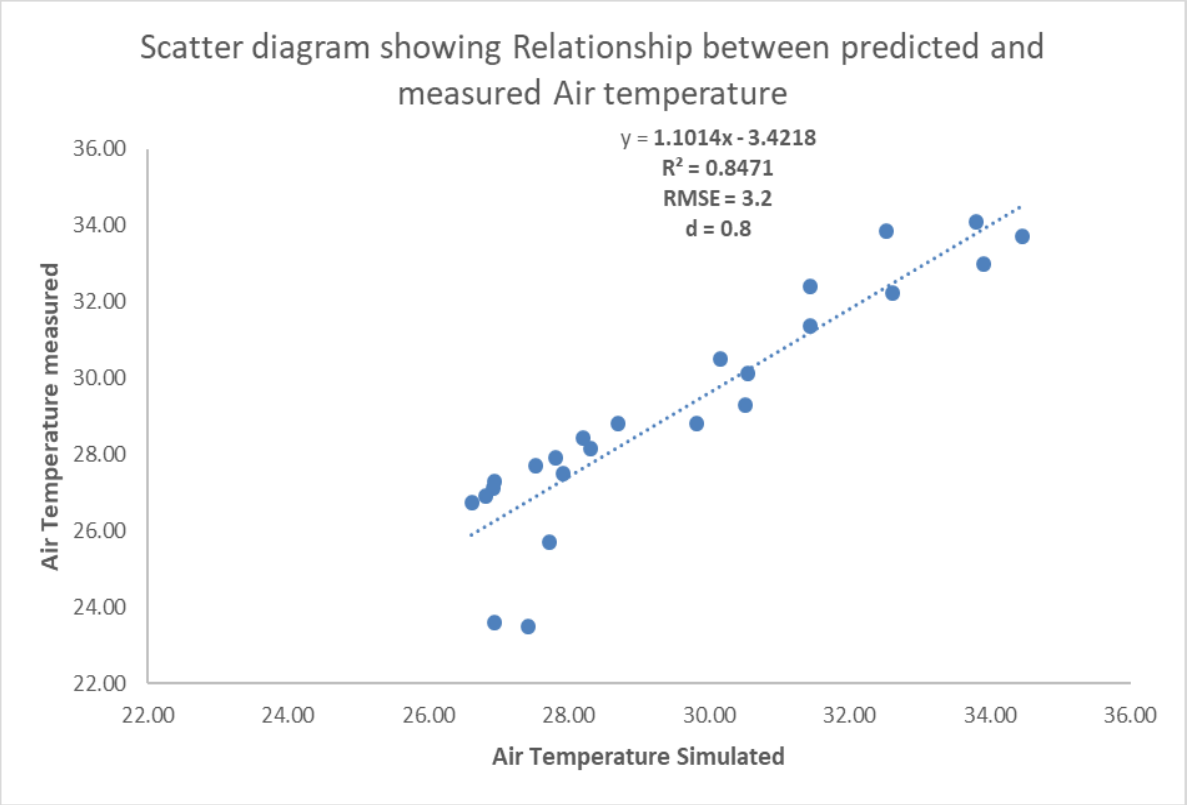

Figure 5: Scatter Diagram Showing the Relationship between Predicted and Measured data

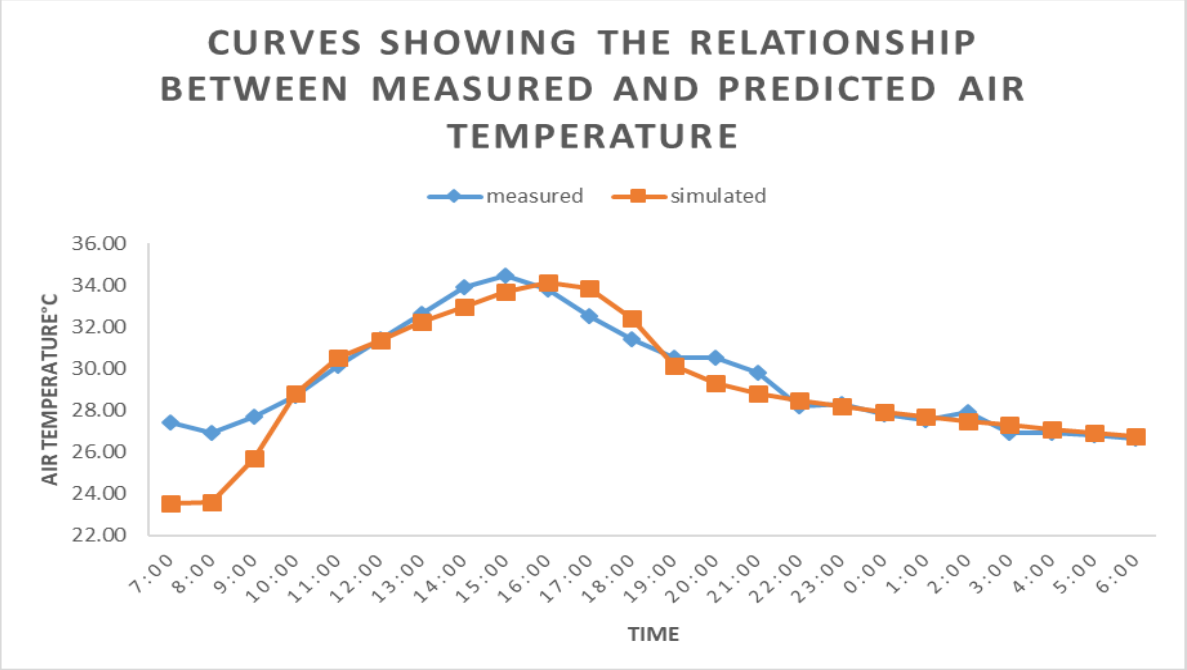

Figure 6: Graph showing the Relationship between Predicted and measured Air temperature

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Studies have shown that RMSE (i.e. systematic and unsystematic root mean square error), and the index of agreement, are important in model evaluation. The coefficient of determination R^2 (should between 0.5 – 1.0), and the index of agreement d (should be at least 1.0) is important for a better correlation between the measured (O) and the predicted (P) data. Index of agreement usually the level of error-free, while RMSEs, and RMSEu values are significant as they can indicate errors in the design of the model.(Willmott, 1982),(Willmott *et al*., 1985)

Actually, results from the Table 1 show that the value R^2 of 0.8<1 is a statistically significant correlation, apparently, index of agreement (d) value at 0.8<1, indicating that the model performed well. The RMSEu was close to the overall value of RMSE, and the RMSEs is greater than 1, which confirms that the large RMSEs value is as good as possible under this condition(Stunder and SethuRaman, 1986)

4. Conclusions

This study presents a validation of measured and predicted air temperatures in a courtyard of a shophouse in Malacca using Envi-met software. Both the measured and the predicted data taken for seven days and simulations conducted; using statistical analysis, the degree of agreement is 0.8, which is significant. This shows that the Envi-met software well validated for further analysis as all the parameters are behaving well. This method of validation can also extend to other simulation software that uses the outdoor environment.

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