7.3 VALIDATION OF MODELLED MEAN RADIANT TEMPERATURE WITHIN URBAN STRUCTURES

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1. INTRODUCTION

For the comprehensive evaluation of the thermal bioclimate of humans it is necessary to consider, amongst other factors, all the meteorological parameters which affect the human energy balance. They are summarized as thermal factors (VDI, 1998). The mean radiant temperature T_{mrt} is the most important meteorological input parameter to obtain the human energy balance during summer weather conditions and shows the greatest variations. Therefore, T_{mrt} has the strongest influence on thermophysiological significant indices (MATZARAKIS, 2000) which are derived from models for the human energy balance (MAYER, 1993).

The objective of this paper is to present comparisons of measured T_{mrt} in urban areas and estimated T_{mrt} by RayMan model (MATZARAKIS et al., 2000)

2. METHODS

The mean radiant temperature can either be obtained from separate measurements of solar (shortwave) and terrestrial (longwave) radiation fluxes or by integral measurements (HÖPPE, 1992, MATZARAKIS, 2000).

In literature, methods of estimating radiation fluxes based on parameters including air temperature, air humidity, degree of cloud cover, air transparency and time of the day of the year have been well documented. The albedo of the surrounding surfaces and their solid angle proportions must also be specified.

The model RayMan (Fig. 1) which is presented here is well-suited for the calculation of radiation fluxes especially within urban structures, because it takes into consideration various complex horizons (MATZARAKIS et al., 2000).

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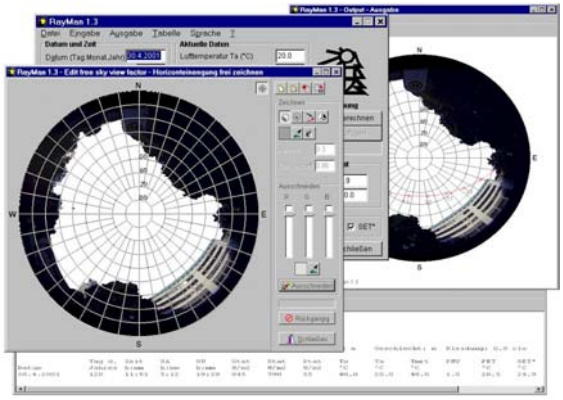

FIG. 1. Window menus of *RayMan* 1.3 allowing import and export of urban structures for the calculation of mean radiant temperature T_{mrt} and thermal indices.

In the field of urban climatology and human-biometeorology the most important question is, how an object of interest is exposed to radiation field conditions especially if the object is shaded or not. Hence, in the presented model the 3-D radiation field and shading by urban and natural obstacles is included.

The final output of the model is however the calculated mean radiant temperature which is required in the energy balance model for humans and thus for the assessment of urban bioclimate and the resulting thermal indices, e.g. PET (MATZARAKIS, 2000). The model is developed based on the German VDI-Guidelines 3789, Part II (VDI, 1994), Part III (2001) and 3787 Part I (VDI, 1998).

3. RESULTS

As a typical example Fig. 2 gives the relationship between the measured T_{mrt} and the humanbiometeorological thermal index PET. The latter refers to measurements at different sides of streets and under a tree, and are market out as the measurement sites for human-biometeorological evaluations of urban structures. They are well correlated.

Fig. 3 gives the relationship between modelled T_{mrt} with RayMan and measurements that were carried out on July 17th, 18th, 19th, 25th and August 2nd 2001 in Freiburg, south-west Germany.

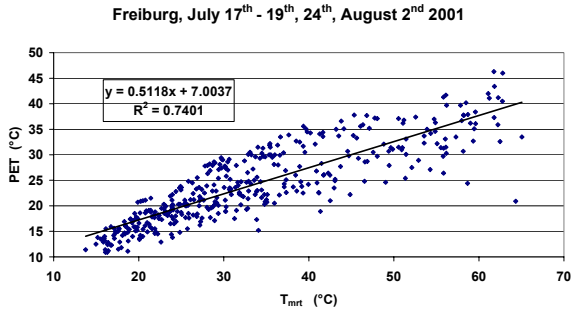

FIG. 2. Relationship between T_{mrt} and PET for July 17th, 18th, 19th, 25th and August 2nd 2001 in Freiburg.

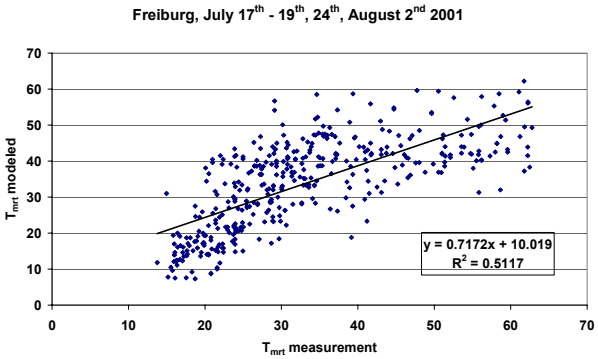

FIG. 3. Relationship of measured mean radiant temperature $T_{mrt\ measurement}$ and computed mean radiation temperature $T_{mrt\ modeled}$ by RayMan for July 17th, 18th, 19th, 25th and August 2nd 2001 in Freiburg.

Fig. 3 shows large scattering in the statistical relationship between T_{mrt} measured and modelled, which can be explained by the method used. On the one hand clouds are not considered. On the other hand, the difference could be due to the effect of the extremely complex structures at the measurement sites. Nevertheless the simulation of T_{mrt} by RayMan is in agreement with measured values.

CONCLUSIONS

For the evaluation of thermal component of urban and regional climate precise and high resolution radiation data of the whole surrounding is necessary.

Results emanating from the model RayMan are validated with the results from micro-meteorological measurements in urban areas in Freiburg. This validation shows that the calculated mean radiant temperature by RayMan agrees with the measured values. The calculation of radiation fluxes in complex structures by RayMan is an easy way to obtain data for the determination of the thermal component of urban climate and thermal bioclimate.

RayMan is able to do the latter and is available for general use (http://www.mif.uni-freiburg.de/rayman).

REFERENCES

Matzarakis, A., 2000: Modelling of radiation fluxes in urban areas and their relevance to thermal conditions of humans. Third Symposium on the urban environment. 163-164.

Matzarakis, A.; Rutz, F.; Mayer, H., 2000: Estimation and calculation of the mean radiant temperature within urban structures. In: Biometeorology and Urban Climatology at the Turn of the Millenium (ed. by R.J. de Dear, J.D. Kalma, T.R. Oke and A. Auliciems): Selected Papers from the Conference ICB-ICUC'99, Sydney, WCASP-50, WMO/TD No. 1026, 273-278.

Mayer, H., 1993: Urban bioclimatology. *Experientia* **49**, 957-963.

VDI, 1994. VDI 3789, Part 2: Environmental Meteorology, Interactions between Atmosphere and Surfaces; Calculation of the short- and long wave radiation. Beuth, Berlin. pp. 52.

VDI, 1998: VDI 3787, Part I: Environmental meteorology, Methods for the human biometeorological evaluation of climate and air quality for the urban and regional planning at regional level. Part I: Climate. Beuth, Berlin. pp. 39.

VDI, 2001: VDI 3789, Part 3: Environmental Meteorology, Interactions between Atmosphere and Surfaces; Calculation of spectral irradiances in the solar wavelength range. Beuth, Berlin. pp 77.