Annalen der Meteorologie 41, Vol. 2, 631-636

APPLICATION OF RAYMAN FOR TOURISM AND CLIMATE INVESTIGATIONS

Andreas Matzarakis[1], Frank Rutz[2]
[1] Meteorological Institute, University of Freiburg, Germany
[2]TU Braunschweig, Germany

1 INTRODUCTION

Because of the limited daily mobility of tourists, the most important effects of climate on tourism take place at the local level. These effects are significant for both the tourism industry and the owners of holiday homes themselves, but they are also of importance to the planning and design of tourism buildings, recreation facilities and a variety of other issues. With some modification, existing methods for assessing climate in human biometeorology and applied climatology can be applied for tourism climatology (Matzarakis et al., 2004).

For example, thermal indices that are derived from the energy balance of the human body can be of great use for tourism. Standard climate data, such as air temperature, air humidity and wind speed are required in order to calculate and quantify the thermal bioclimatic conditions. The most important environmental parameters for deriving modern thermal indices, however, are the short and long wave radiation (and the derived mean radiant temperature). These can be determined using special techniques. The RayMan model, which has been developed for urban climate studies, has a broader application spectrum, i.e. tourism climatology (Matzarakis et al., 2004). Further outputs as sunshine duration and shadow can be helpful in the design and structure of tourism facilities and recreation areas.

2 METHODS

The model „RayMan“ estimates the radiation fluxes and the effects of clouds and solid obstacles on short wave radiation fluxes (Fig. 1). The model, which takes complex structures into account, is suitable for usage and planning purposes in different local to regional levels (Fig. 2 left). The final output of this model is the calculated mean radiant temperature, which is required in the energy balance model for humans. Consequently, it is also required for the assessment of urban bioclimate and such thermal indices as Predicted Mean Vote (PMV), Physiologically Equivalent Temperature (PET) and Standard Effective Temperature (SET*). The model is developed based on the German VDI-Guidelines 3789, Part II: Environmental Meteorology, Interactions between Atmosphere and Surfaces; Calculation of the short- and long wave radiation and VDI-3787: 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. For the calculation of thermal indices based on the human energy balance, meteorological (air temperature, wind speed, air humidity and short and long wave radiation fluxes) and thermo physiological (activity and clothing) data are required. Data on air temperature, humidity and wind speed have to be available to run RayMan (Matzarakis et al., 1999).

Additional features, which can be used for the evaluation of a region’s climate or the development of new tourism facilities are: a) calculation of sunshine duration with or without sky view factors; b) estimation of daily mean, max or total global radiation; and c) determination of shaded areas as outputs of RayMan.

When using the computer software “RayMan” (Fig. 2 left) an input window for urban structures (buildings, deciduous and coniferous trees) is provided. The possibility of free drawing and output of the horizon (natural or artificial) are included for the estimation of sky view factors (Fig. 2 right). The input of fish-eye-photographs for the calculation of sky view factors is also possible. The amount of clouds covering the sky can be included by free drawing while their impact on the radiation fluxes can be estimated (Matzarakis 2001).

In the field of applied climatology and humanbiometeorology the most important question about radiation properties on the micro scale is whether or not an object of interest is shaded. Hence, in the presented model shading by artificial and natural obstacles is included.

Horizon information (in particularly Sky View Factor) needs to be known to obtain sun paths (Fig. 3 left). Calculation of hourly, daily and monthly averages of sunshine duration, short wave and long wave radiation fluxes with and without topography and obstacles in urban structures can be carried out with *RayMan* (Fig. 3 left). Data can be entered through manual input of meteorological data or pre-existing files. The output is given in form of graphs and text data (Fig. 2 right, Fig. 3 left and right).

The model RayMan is developed based on the German VDI-Guidelines 3789, Part II (VDI 1994) and VDI-Guideline 3787 Part I (VDI 1998).

3 RESULTS AND DISCUSSION

The RayMan model can be applied for diverse applications. Results can even be produced without any meteorological or climatological data. Thus, it is of use for the quantification of sunshine duration at a given point with and without limited horizon (Fig. 3 and 3). Results on mean or total monthly sunshine duration can easily be presented for a variety of environments (Tab. 1 based on the building and vegetation data from Fig. 2 and 3). The calculations of a possible building and vegetation morphology presented in Table. 1 have been carried out for Freiburg, Germany, in a latitude of 49 °N.

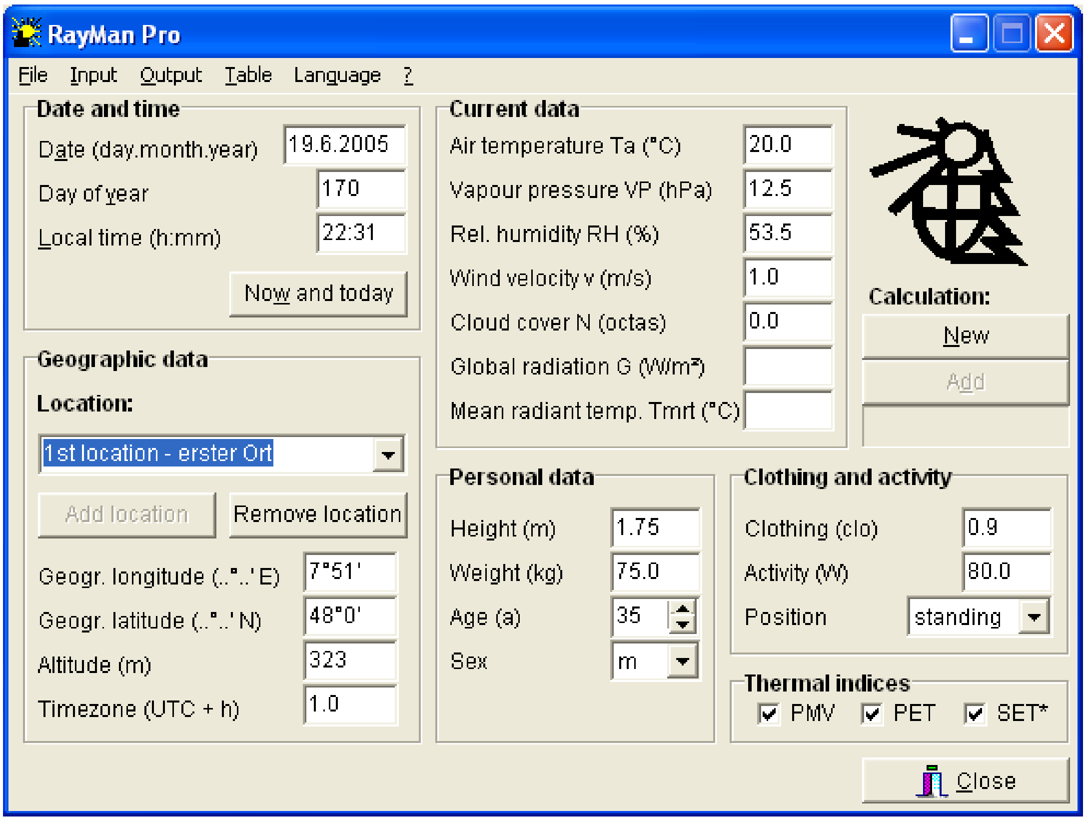

Fig: 1: Main window of RayMan

With existing meteorological or climatological data the RayMan model can be applied for the estimation of thermal indices such as PMV, PET or SET*, which are based on the human energy balance. Additionally, selected energy fluxes and thermo-physiological parameters, based on the MEMI (Munich Energy Balance Model for Individuals) can be derived. The thermal indices can be used for the quantification of the thermal conditions in several climate regions and environments. The derived output from MEMI can constitute the basis to understand and discover the energy fluxes for specific studies and analyses.

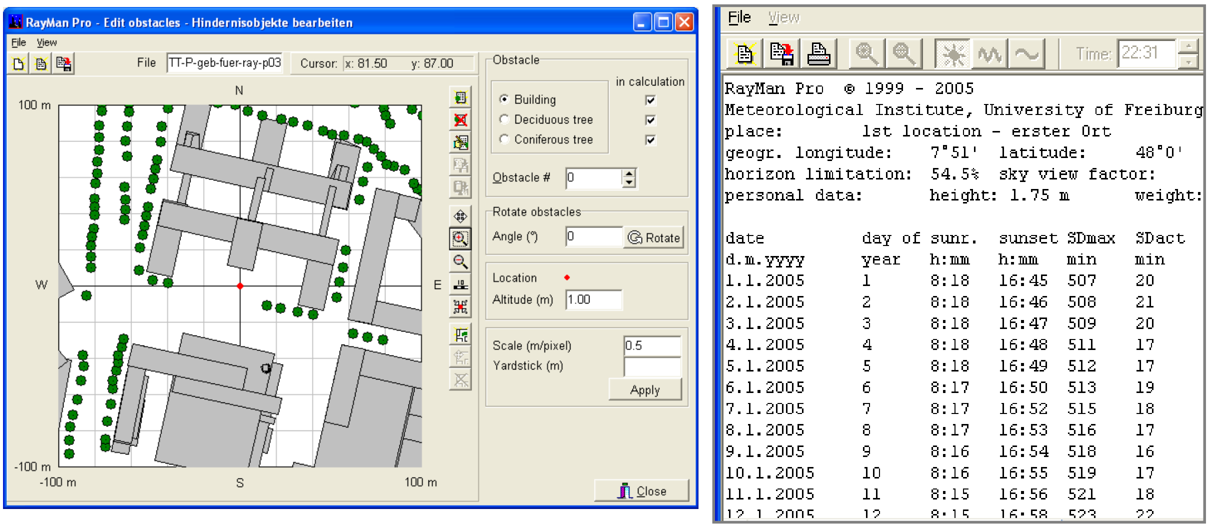

Fig: 2: Window for buildings and vegetation input (left) and data output for SVF and sunshine duration in RayMan

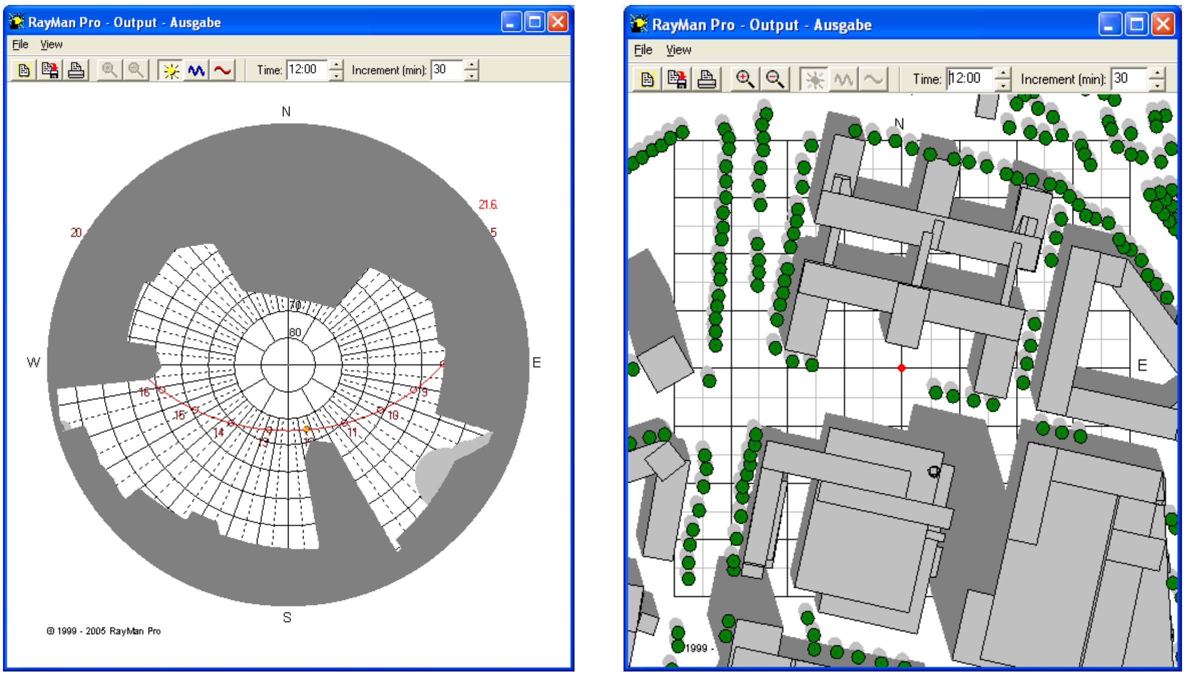

Fig: 3: Example of sun path (left) and shadow (right) for June 21 for a complex environment

Table 1: Total monthly sunshine duration for the location from fig. 2

Month	1	2	3	4	5	6	7	8	9	10	11	12
Sdmax (h)	8.9	10.2	11.9	13.7	15.2	16.0	15.6	14.3	12.6	10.9	9.3	8.5
Sdmean(h)	1.0	4.4	7.5	8.0	8.3	8.6	8.5	7.8	8.2	5.7	1.9	0.3
Sdsummax(h)	275.5	286.4	369.0	409.8	470.5	479.3	483.6	442.6	377.9	336.5	278.9	262.1
Sdsummean	30.2	121.8	231.8	240.1	256.7	257.6	264.5	243.3	245.2	175.7	58.5	8.8
Ratio (%)	11.0	42.5	62.8	58.6	54.6	53.7	54.7	55.0	64.9	52.2	21.0	3.4

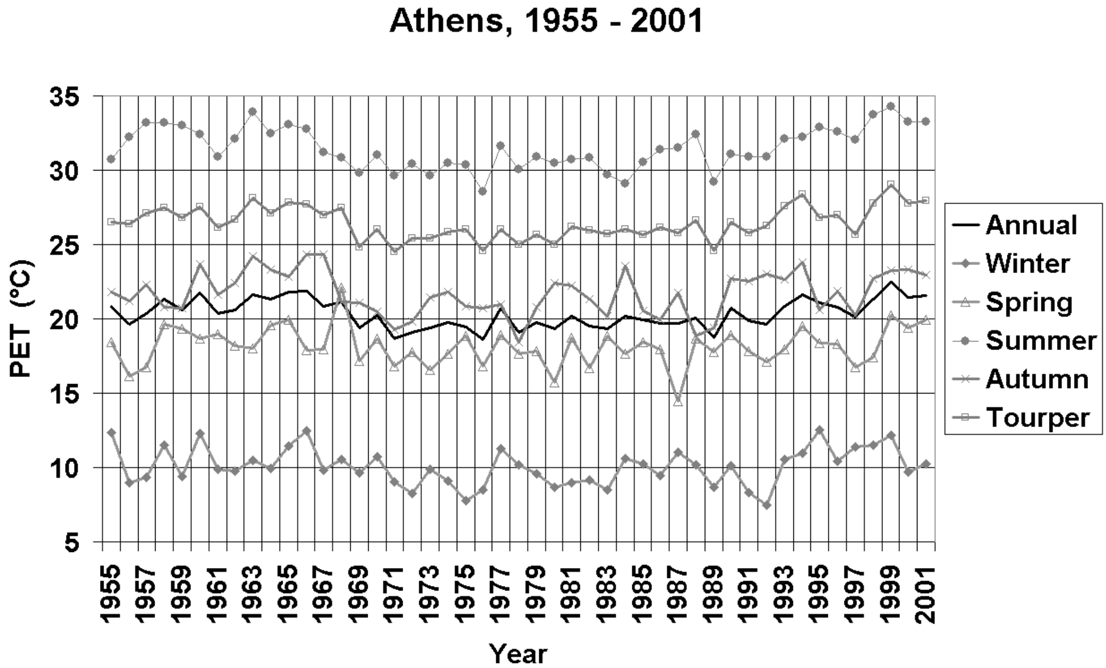

Fig. 4: Seasonal, annual and tourism period (April to October) trend of PET for Athens, Greece for the period 1955-2001.

Fig. 4 shows the trend of the Physiological Equivalent Temperature (PET) based on daily data for Athens for the period 1955 – 2001. The figure also shows calculations of PET for individual seasons, the whole year and the tourism period (April to October) based on monthly means.

4 CONCLUSION

The presented model provides diverse opportunities in applied climatology and also tourism climatology. Useful information can be derived in order to create climate oriented dwellings and facilities for tourism resorts. It can also be used for the calculation of shade to be provided by special devices in tourism areas and resorts in order to create more comfortable thermal conditions with protection from direct sunlight for recreational users and visitors.

Form the human-biometeorology point of view the offered thermal indices can describe and quantify not only mean conditions but also extremes like heat waves.

REFERENCES

Matzarakis, A., Mayer, H., and Iziomon, M.G., 1999: Applications of a universal thermal index: physiological equivalent temperature, Int. J. Biometeorol. 43: 76-84.

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.

Matzarakis, A., de Freitas, C., Scott, D., 2004 (eds.): Advances in tourism climatology. Ber. Meteorol. Inst. Univ. Freiburg Nr. 12.

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: Methods for the human-biometerological assessment of climate and air hygiene for urban and regional planning. Part I: Climate, VDI guideline 3787. Part 2. Beuth, Berlin.