CLIMATE CHANGE SCENARIOS AND TOURISM – HOW TO HANDLE AND OPERATE WITH DATA

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ABSTRACT Climate runs with climate scenarios provide many climatological parameters and information at several temporal and spatial scales. Regional climate models, e.g. REMO, produce data at a spatial resolution of 10 km and a temporal scale of one hour. These data files for diverse climate scenarios, e.g. A1B, are huge and it is difficult to do calculation with them. The existing data sets can be downloaded but the format and the size are not so easy to process for normal users. Therefore, as part of the CAST-project, several software programs were developed in order to operate and process those data. The software modules include routines for the download and extraction of specific data sets (daily or hourly, max or min) and specific parameters, e.g. air temperature and wind speed. The output is prepared in order to run single grids or to focus on specific regions of the REMO area. Additionally, the output can deliver data, which is used as input data for the RayMan model to run thermal indices and to calculate the mean radiant temperature. Single grid cells can be processed with the usual software packages. Additional analyses, e.g. CTIS, require additional programs, which can produce the climate-tourism diagrams.

For the spatial visualisation of relevant data, e.g. air temperature or PET, the use of simple rather than complex GIS-systems can be an easy solution. Therefore, a climate mapping tool (mini GIS) was developed for the construction of maps of climatological and other parameters.

KEYWORDS *Climate model data, tourism, climate tools, RayMan, CTIS, climate mapping tool*

INTRODUCTION

In the last decades, new information and software technologies were developed which provide us with many opportunities for data processing. Nevertheless, the data has to be available and suitable for the particular analysis (Matzarakis et al., 2004). At the moment two possible sources exist: data from climate networks and modelled data. Climate model data for tourism

purposes have to be at least at a meso scale resolution (best resolution at the moment 10 km) (Jacob et al., 2001). The data allow us to process them and produce valid information for tourism purposes, not only from the original data but also from processed data (a.e. calculation of thermal indices) (Matzarakis, 2007).

The main advantages of these data (measured or modelled) can limit their use, because of the huge size and complexity of processing. Since the files are so huge, commonly used software packages cannot handle these data easily.

METHODS AND DATA

As part of the CAST-Project (Heinrichs et al., 2007) and Startclim.2006.D2 (Koch et al, 2007) several tools have been developed. Additionally, the RayMan model is also suitable for use in tourism climatology (Matzarakis et al., 2007).

The data can be drawn from climate networks and long data series (Matzarakis et al., 2005, Matzarakis, 2007, Koch et al., 2007) or from climate models. In our study the original data are based on the regional climate model REMO from the Max-Planck-Institute of Meteorology in Hamburg (Jacob et al., 2007). The model region encompasses Germany and the Alps. The data has a spatial resolution of 10 km and a temporal resolution of hours. The data is available from 1950 until 2100. In that way, the period 1961-1990 of the A1B, A2 and B1 scenario can be used as the reference period for future climate change. Based on hourly or daily values of the scenarios, tourism climatological information can be extracted.

For this study, we developed several ways (tools and software) of processing the data from climate networks and climate models:

a) REMO extractions and processing procedures,
b) RayMan model for the calculation of thermal indices and other radiation properties (Matzarakis et al., 2007),
c) Example of a frequency distribution for PET and precipitation (Matzarakis et al., 2007),
d) Software for the creation of CTIS diagrams,
e) Climate Mapping Tool for the creation of maps of tourism climatological parameters.

RESULTS AND EXAMPLES

REMO data process unit

The REMO data extraction tools (Fig. 1) can extract data from the REMO model (more than 60 parameters) in form of exactly defined grid points or areas for defined regions by coordinates. The software extracts data for different time periods starting in 1961 and ending

in 2100. The available scenarions A1B, A2 and B1 can be selected also specific months in order to reduce the data size. The relevant parameters can be selected and then downloaded.

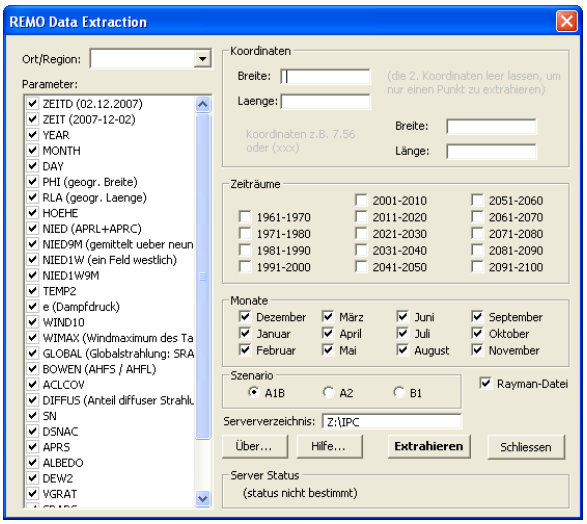

Figure 1: Remo-Data extraction software

Additionally, a second data file can be produced, which can be used directly for RayMan calculations. The program is written in Python language and works on windows-based computers.

RayMan Model

The model „RayMan“ estimates the radiation fluxes and the effects of clouds and solid obstacles on short wave radiation fluxes (Fig. 2, right). The model, which takes complex structures into account, is suitable for utilization and planning purposes on a local and regional level (Fig. 2, left). The final output of this model is the calculated mean radiant temperature, which is required in the energy balance model of humans. Consequently, it is also required for the assessment of urban bioclimate and thermal indices, such as Predicted Mean Vote (PMV), Physiologically Equivalent Temperature (PET), and Standard Effective Temperature (SET*). The development of the model is 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 (VDI, 1994, 1998). For the calculation of thermal indices based on the human energy balance meteorological data (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 are required to run RayMan (Matzarakis et al., 2007). The software is written in Borland Delphi.

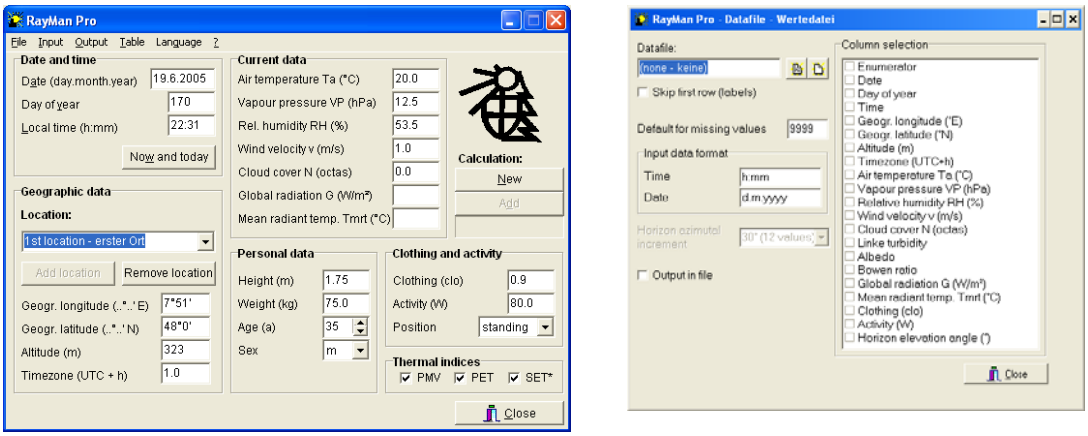

Figure 2: RayMan software for the calculation of thermal indices and radiation

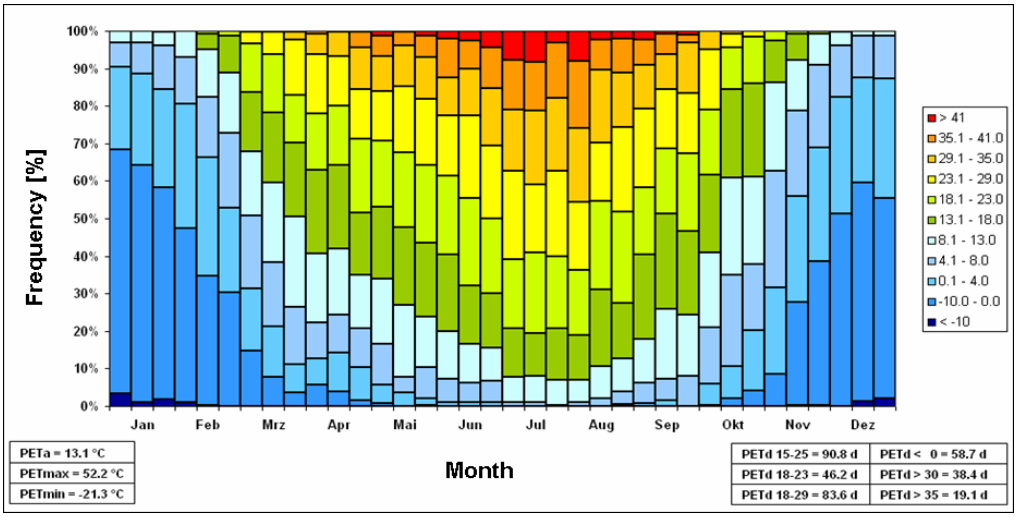

Figure 3: Frequency diagram (produced by Microsoft Excel)

Frequency diagrams

The frequency diagrams (Fig. 3) can be produced with regular software a.e. Microsoft Excel. The diagrams are based on pivot tables and then the frequencies are calculated with Excel. Fig. 3 gives an example how a diagram looks like. The diagrams can not only be used for PET diagrams (Matzarakis et al., 2007), but also for other climatic parameters, a.e. precipitation or wind classes.

Climate-Tourism-Information-Scheme Software

Based on the Climate Tourism Information Scheme (CTIS) (Matzarakis et al., 2007) a software tool has been developed in order to produce CTIS-diagrams. The diagrams can be produced for

a resolution of months, decades and weeks. Both factors to be included, parameters and colours can be chosen (Fig. 4). The output can be stored in ordinary graph formats, a.e. jpg or png.

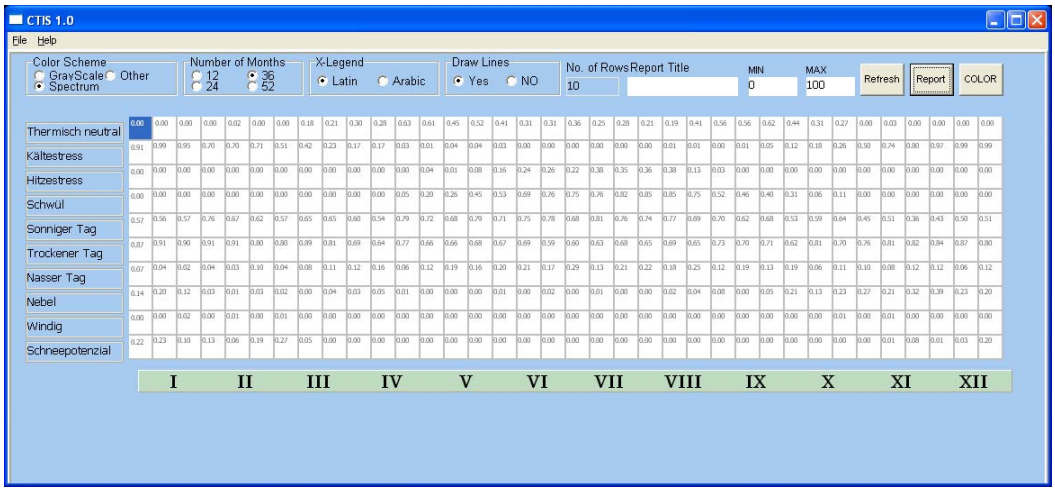

Figure 4: Software for the creation of the Climate-Tourism-Information-Scheme

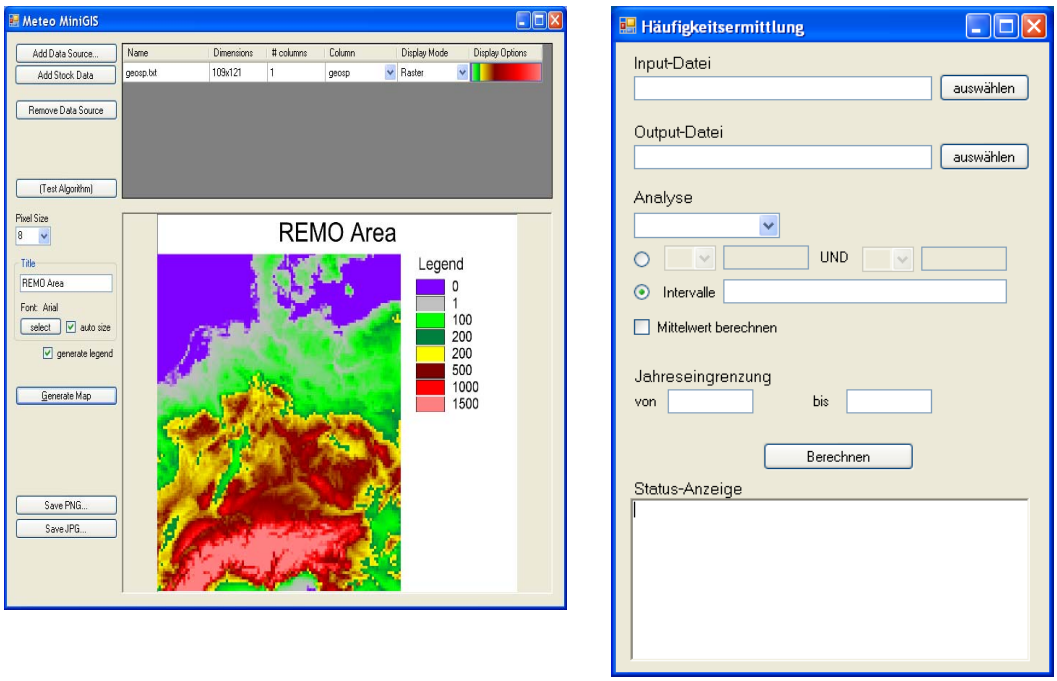

Figure 5: Climate mapping tool software (left) and calculate (right)

Climate Mapping Tool and calculate

Data in climatology and meteorology can be spatially represented or.visualized through the use of. GIS techniques, but these are expensive and not easy to use. Here, we produce a tool which can generate maps based on ascii files. We can create colour plots, isolines or combined graphs. The processing of data is very easy and user friendly. This possibility of showing or visualizing data is easy understandable and easy to use. Several data sets can be imported and processed in

the Climate Mapping Tool (Fig. 5 left). For quick analysis and calculation of frequencies and means of thershols values the software tool calculate can be used (Fig. 5 right).

CONCLUSIONS

In the past, both the analysis with huge data files and their mapping were difficult because of the problems in obtaining and processing of climatological data. The development of new process and visualisation techniques provide new opportunities, but they are expensive and time demanding. The possibilities and tools presented here do not require much time for learning and they are user friendly. They do not have any limitations regarding data size and also have less running time for processing. They are free available and easy understandable. The tools presented here offer a range of possibilities, not only in the fields of applied climatology and tourism climatology

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REFERENCES

Jacob, D., Andrae, U., Elgered, G., Fortelius, C., Graham, L. P., Jackson, S. D., Karstens, U., Koepken, Chr., Lindau, R., Podzun, R., Rockel, B., Rubel, H.B., Sass, R.N.D., Smith, B.J.J.M., Van den Hurk, X. Yang, X. (2001) A Comprehensive Model Intercomparison Study Investigating the Water Budget during the BALTEX-PIDCAP Period. Meteorology and Atmospheric Physics 77, 19-43.

Koch, E. Matzarakis, A., Rudel, E. (2007) Anpassung des Sommertourismus an den Klimawandel in Österreich. StartClim 2006.D2: erste Ergebnisse. Ber. Meteor. Inst. Univ. Freiburg Nr. 16, 80-86.

Heinrichs, H., Jetzkowitz, J., Kreilkamp, E., Matzarakis, A., Möller, A., Michelsen, G. (2007) KUNTIKUM: Klimatrends und nachhaltige Tourismusentwicklung in Küsten- und Mittelgebirgsregionen: Produkt und Infrastruktur-Innovation durch kooperative Lernprozesse und strategische Entscheidungsfindung. Ber. Meteor. Inst. Univ. Freiburg Nr. 16, 87-93.

Matzarakis, A. (2007) Entwicklung einer Bewertungsmethodik zur Integration von Wetter- und Klimabedingungen im Tourismus. Ber. Met. Inst.Univ. Freiburg 16, 73-79.

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

Matzarakis, A., Rutz, F., Mayer, H. (2007) Modelling Radiation fluxes in simple and complex environments – Application of the RayMan model. Int. J. Biomet. 51, 323-334.

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 (1994) Methoden zur human-biometeorologischen Bewertung von Klima und Lufthygiene für die Stadt- und Regionalplanung, Teil I: Klima. - VDI-Richtlinie 3787 Blatt 2.