'Urban climate 21' - Climatological basics and design features for 'Stuttgart 21' on CD-ROM

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"Urban climate 21" - Climatological basics and design features for "Stuttgart 21" on CD-ROM

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Abstract: Project "Stuttgart 21" means conversion of an area of about 100 ha by transfering the main railway station of Stuttgart and the adjacent railway tracks underground. This required the consideration of different environmental effects, one of them the climate. The wealth of information, gained in the studies, led to the idea to make these data available on a CD-ROM, called "Stadtklima 21" („Urban Climate 21"). It is a sophisticated source of information, especially for those, involved in the planning of „Stuttgart 21" but also for the public. The information system on the CD-ROM is designed flexible in order to be able to cope with future developments and requests. All together the CD-ROM contains 130 files with information about the area, 100 files with information for single points, 275 files with comments and about 500 photographs and graphics.

Key words: urban climate, information system, cold air flow, urban planning

1. INTRODUCTION

For some time now, in Stuttgart, great attention has been paid to its climatological and air quality features and not without reason. Stuttgarts favourable location in terms of landscape and climate mask certain problematical aspects of its urban climate to be considered in urban planning. These result from the fact, that the densely built-up center of the city is located in a valley basin (Fig. 1). Because of this, the windvelocity, which is low in the Southwest of Germany anyway, is further reduced. This weakens the ventilation of the city and the dilution of air pollutants. Furthermore, low windvelocities facilitate the development of temperature inversions, which in turn further reduce the air exchange (Klimaatlas, 1992).

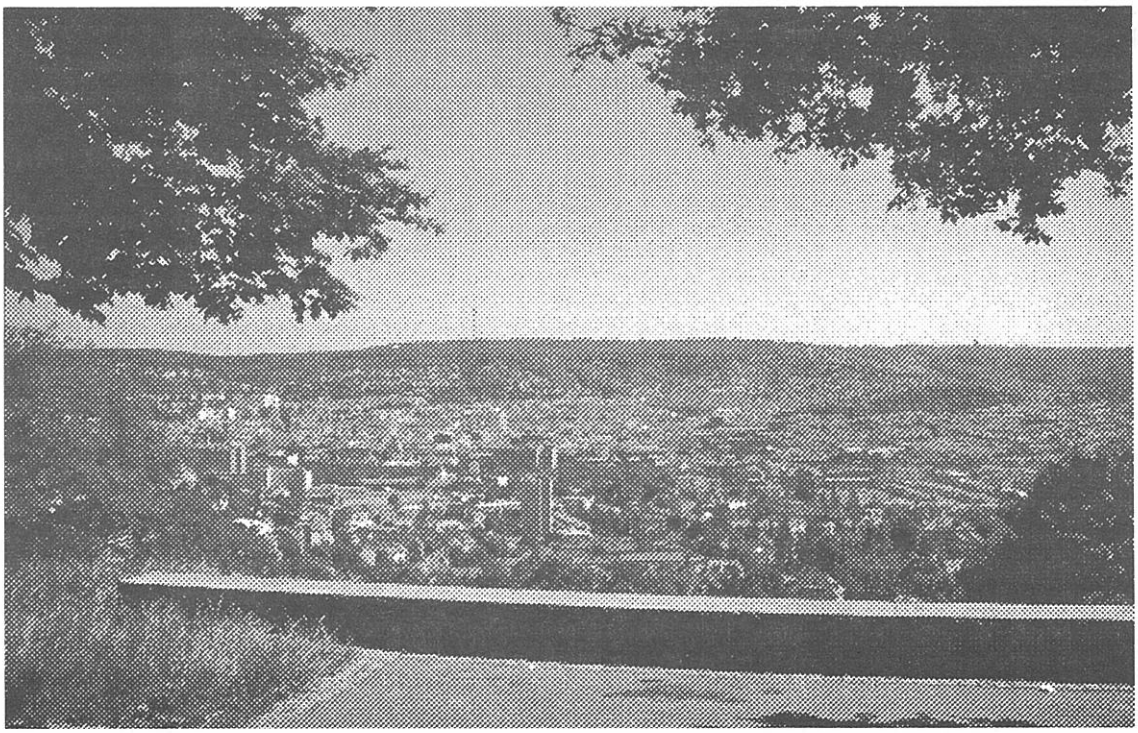

Figure 1 The City of Stuttgart lying in a basin

In calm weather conditions, the pronounced topographical profile of the municipal area with differences in altitude of more than 300 m causes thermally induced local wind systems (Fig. 2), which contribute to ventilation and improvement of air quality. Knowledge of the main ventilation and fresh air paths is a significant element of urban planning in Stuttgart.

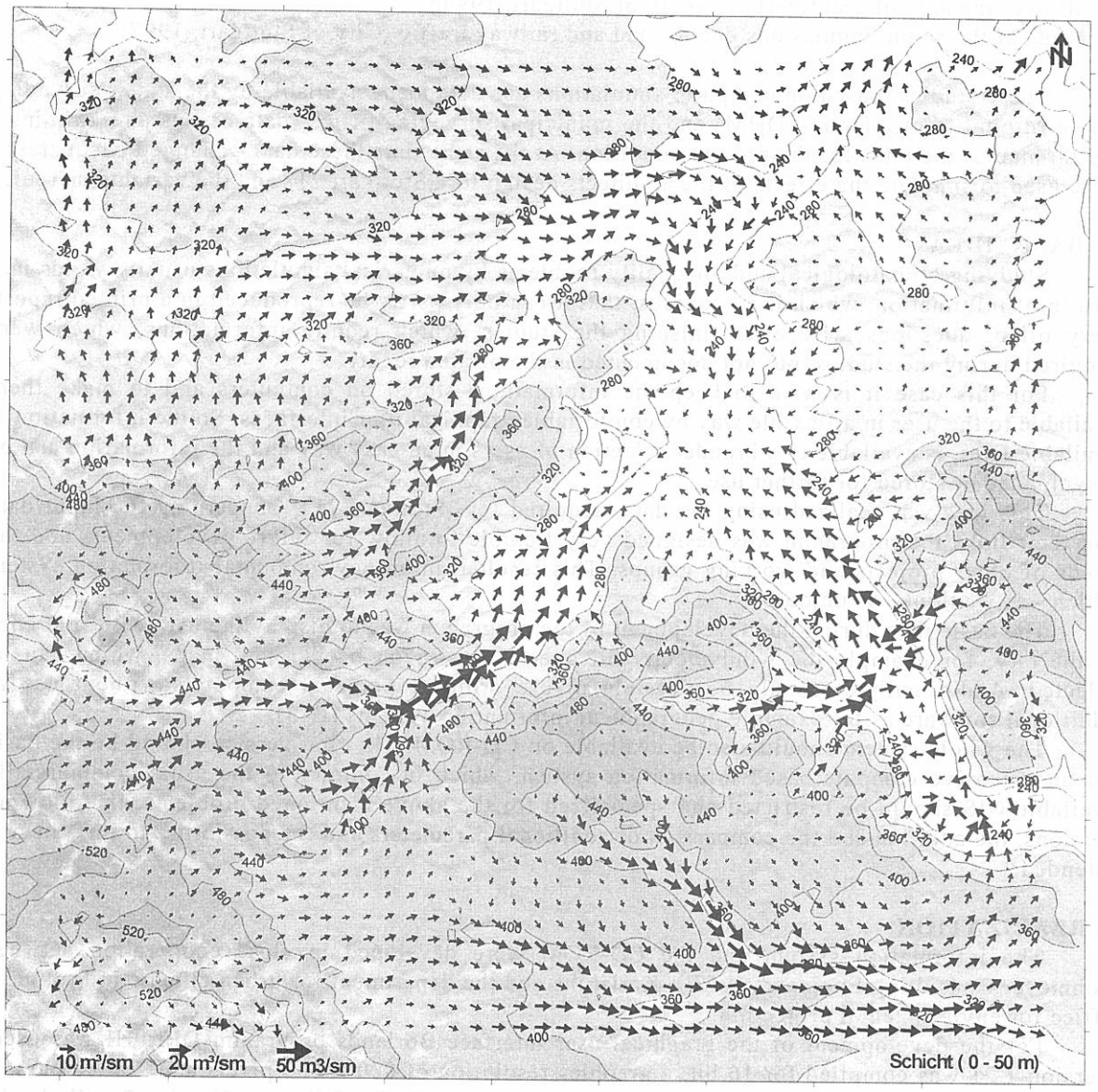

Figure 2 The topography of Stuttgart with local nocturnal cold air-flow densities (m³/ms)

The intended abolition of the railway terminal and the transfer of the rails to the underground implies the conversion of an area of about 100 ha (called "Stuttgart 21") of railway tracks and buildings in the climatological sensitive city basin. Therefore it was necessary to provide and consider the relevant information on climate and air quality as early as possible. These studies consisted of field measurements in the city area and especially in the application of numerical and physical models, for example:

- Calculation of the windvelocities and winddirections all over the area for the present condition, including thermally induced flows. This was done by simulations with a drainage flow model for clear calm nights and with a diagnostic wind field model for the other weather conditions (city of Stuttgart, 1996a)
- Contract Works of the German Weather Service (DWD) for the present condition, concerning the local wind- and temperature conditions in and around Stuttgart 21, using a threedimensional microscale urban climatological model to prepare maps of thermal comfort (PMV, predicted mean vote)
- Calculations of the air pollution caused by vehicles in the vicinity of roads with heavy traffic and all over the area of „Stuttgart 21" (City of Stuttgart, 1996b)
- Maps of the sound immissions due to road and railway traffic (City of Stuttgart, 1997)

These studies, based on computer simulations use data made available by the state's surveying office (digital terrain model, DHM) and the municipal surveying office (data of lots and buildings, digital map of the city) for the present condition. At the same time these data - changed adequately - were used to simulate the effects of the architects design for „Stuttgart 21" and the variants thereof.

2. BASIC IDEA

Studying climatological and air quality problems by numerical simulations usually yields in a wealth of information, which is so copious, that it can only partly be reproduced in a printed report. Very often, questions arise after finishing the studies, which require informations, which were acquired during the studies, but not documented in the printed report.

For this case it is wise to keep the informations stored on computers and to make them available to the user in a flexible way by comfortable graphical user interfaces. So the information is available later, is available to a broader selection of users in an easy way and the information can be downloaded or stored for further use.

This idea was realized using the data, acquired for „Stuttgart 21". Concerning the input data and their links the programm was designed very flexible to allow for future developments and the needs of other projects and working groups. This resulted in an environmental information system which - as we think - is unique.

The basic idea during the development of the programm was to display the data with reference to the city, for example the windvelocity all over the town on background maps, which can be selected. Additionally it should be possible to use ordinary personal computers without use of additional software as for example geographical information systems (GIS).

The whole system should also be available on CD-ROM. The first version should be the basis for an extensive computerbased information system, which in contrary to the usual commercially available GIS should be restricted and specialized for the above mentioned problems. In following versions, the addition and the comparison of additional parameters and the possibility to link them is intended.

3. REALIZATION

The information system and the CD-ROM were developed in close cooperation between Lohmeyer Consulting Engineers (LCE), Karlsruhe and the department for urban climate in Stuttgarts office for environmental protection.

For the development of the graphical user interface Borlands programm DELPHI was used. Version 1.21 was compiled for 16 bit, a graphics resolution of 800 x 600 pixels and 256 colours. It is applicable on Windows 3.xx, Windows 95 and Windows NT. The following Version 2 will also be compiled for 32 bit. As hardware a pentium processor and 16 MB RAM are recommended.

"Urban climate 21" is a windows-programm. It is operated using a mouse (push left key once or twice) and is mostly selfexplaining. All the data are displayed on maps of the city of Stuttgart or of the surrounding region. These maps are stored on the CD in different scales and manners (road map, topographical map etc.). Data, available to certain points or areas on the map are displayed and to be selected by the mouse. They are displayed together with the maps and can be stored on disk for further use. It is possible to display

- pictures, maps, graphics (i.e. bitmap Xfiles like BMP- or WMF-files)
- data for single points (i.e. concentrations, temperatures etc.)
- measured wind roses
- twodimensional fields of scalars (gridded data i.e. concentration distributions)
- twodimensional fields of wind vectors

Additionally, it is possible by integrated executable programms to gain additional information, for any position to be selected by the user on

- forward or backward trajectories of nocturnal drainage flows
- information about velocity and flow rate of nocturnal drainage flow
- synthetic (calculated) wind rose
- a graphic, showing the shading of the sun by the surrounding

Moreover slide shows are available for certain topics.

4. EXAMPLES

The following examples for availabilities should be mentioned:

Data for special points:

Figure 3 shows some possibilities to display results obtainable for special points. Usually it is possible to move and scale all the "windows". The contents of the windows may be printed and partly stored in files.

Gridded data:

In Figure 4 the mean annual temperature is displayed on the background of the city map. Depending on the location, the temperatures vary between 9 and 11 centigrades. By pointing at the exact point with the mouse, a click displays the exact value.

Synthetic wind roses:

By means of the integrated programm it is possible, to calculate wind roses for any location in the city of Stuttgart and to display them on the background of a map or in a separate window (Fig. 5). The synthetic wind roses may be displayed including the nocturnal drainage flow or excluding it.

Trajectories:

Because of the topographie, in Stuttgart nocturnal drainage flows are of extraordinary interest for planning purposes. Therefore a programm was integrated in the information system, allowing to calculate and display the trajectories of the drainage flow (Fig. 6). It is possible, to show the forward - and backward trajectories, i.e. where - at a certain position - the flows comes from and where it goes.

Nocturnal drainage flow information:

In addition to the trajectories of the drainage flow it is possible for any point in the city to ask for further information on it (Fig. 7). Besides total thickness of the layer of the flow, mean velocity and flow direction one gets the vertical profile of the specific flow rate and the flow velocity in vertical intervals of 5 m.

Diagramm of sunshine duration:

The topographie of Stuttgart partly shades the city, resulting at some places in substantial losses of sunshine duration and solar radiation. Therefore the integrated programm allows for any point in the city to calculate this shading (without the influence of buildings) and to compare it to the track of the sun for different months (Fig. 8).

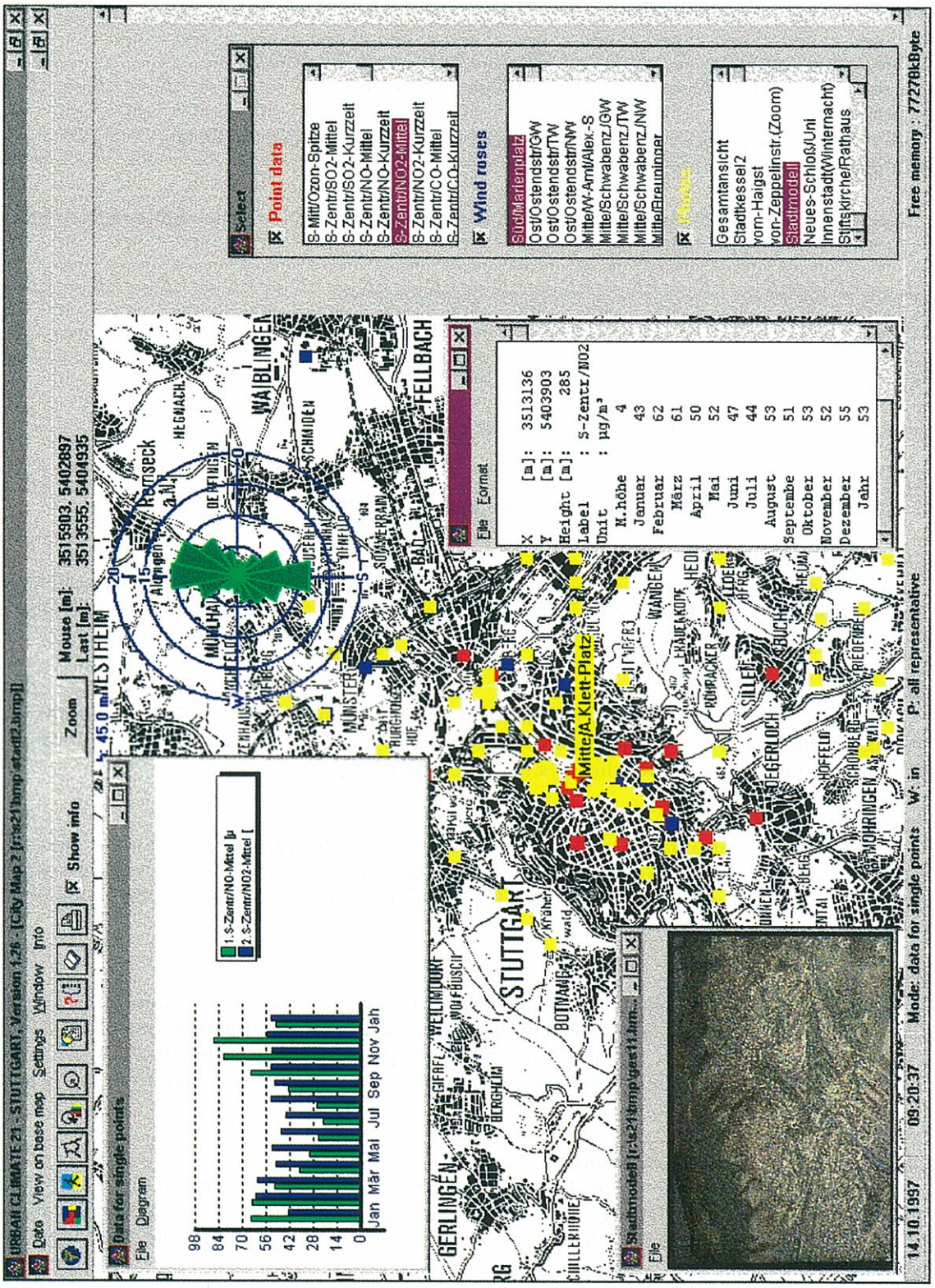

Figure 3 Screenshot: Plot of some measured data for a special point in Stuttgart

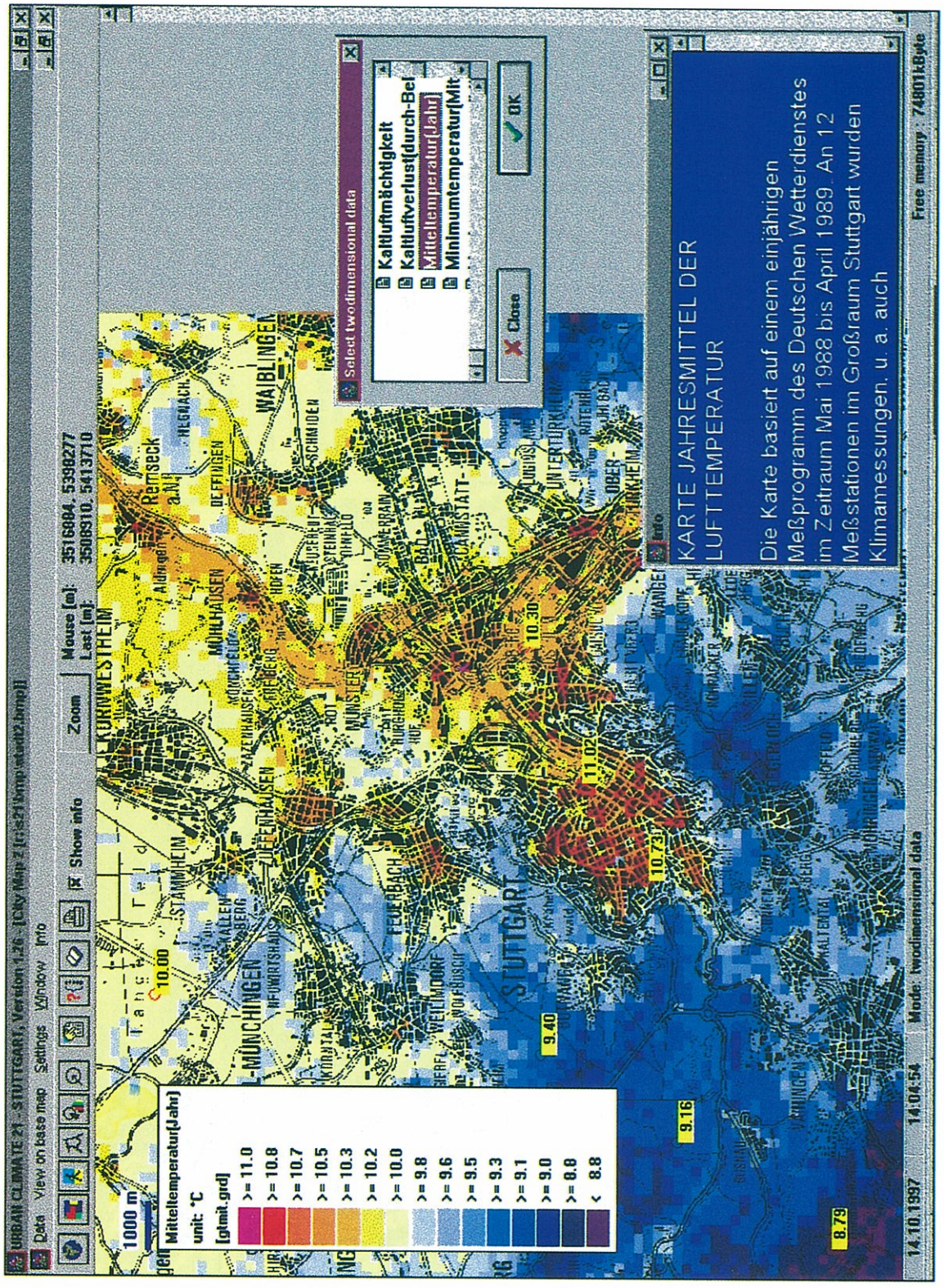

Figure 4 Screenshot: Mean annual temperature on a map of Stuttgart as example for grid-informations

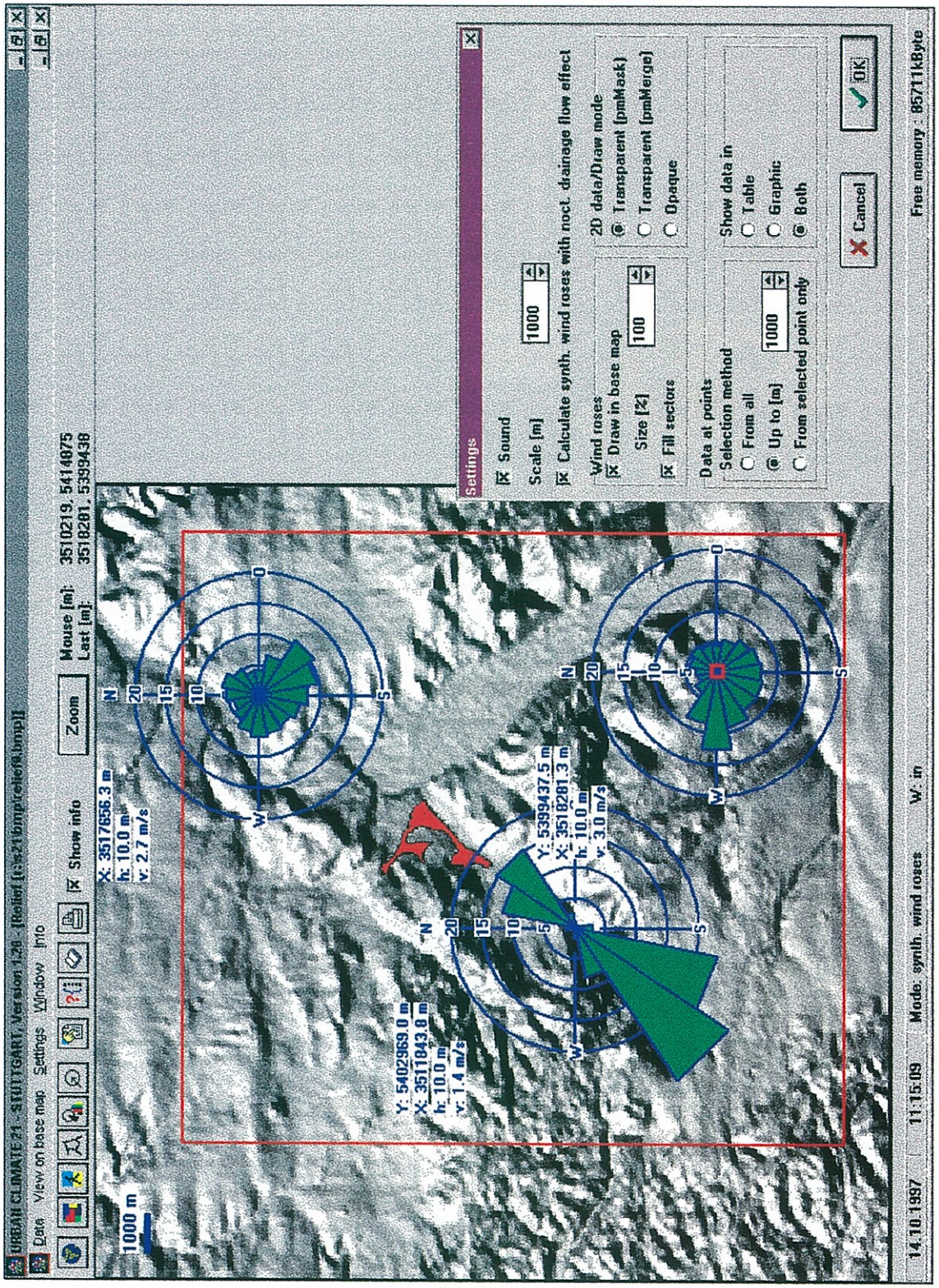

Figure 5 Screenshot: Calculated synthetic wind roses ploted on a relief-map of Stuttgart and a wind rose in a separate window

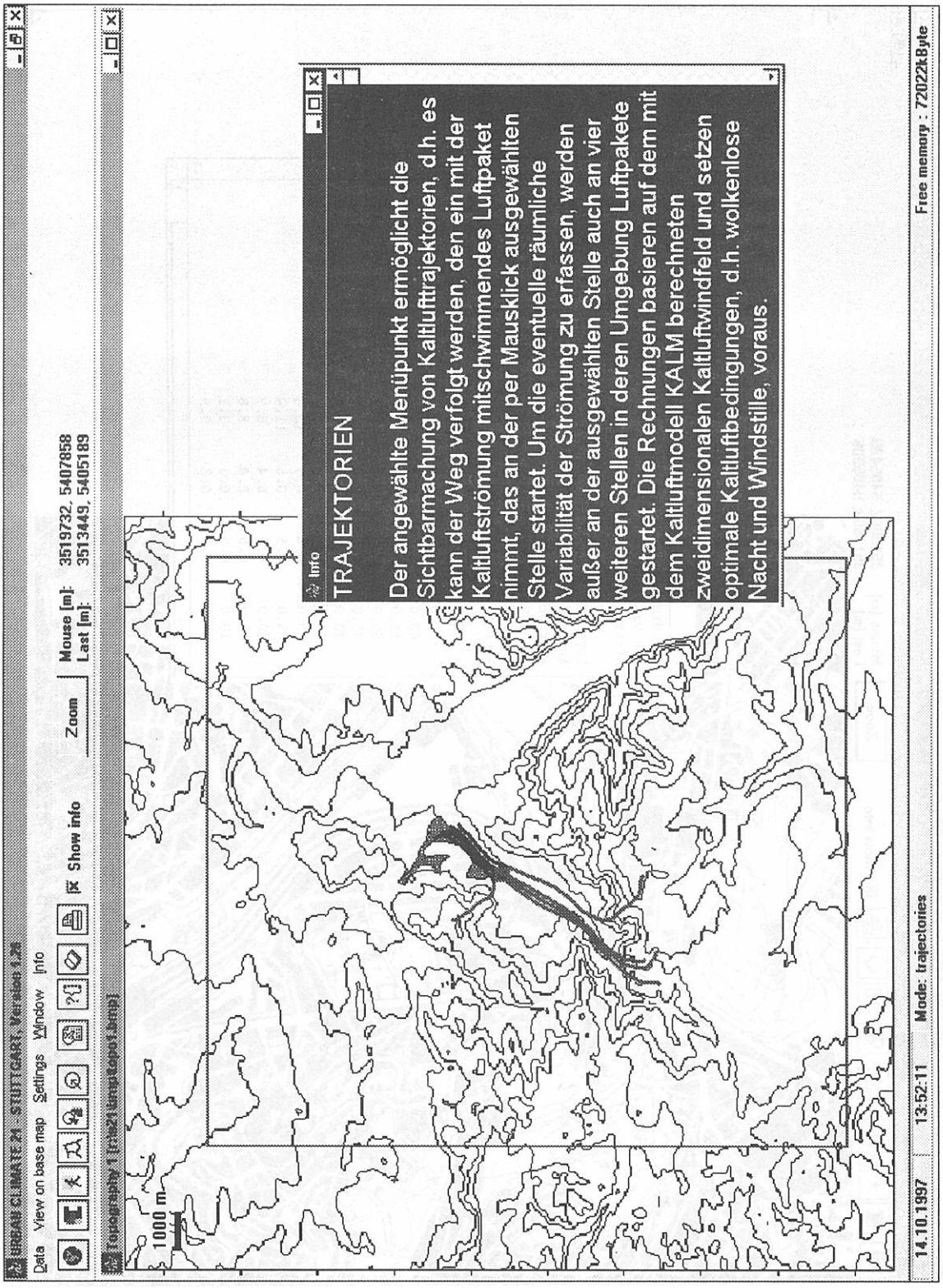

Figure 6 Screenshot: Plot of calculated trajectories on a map of Stuttgart

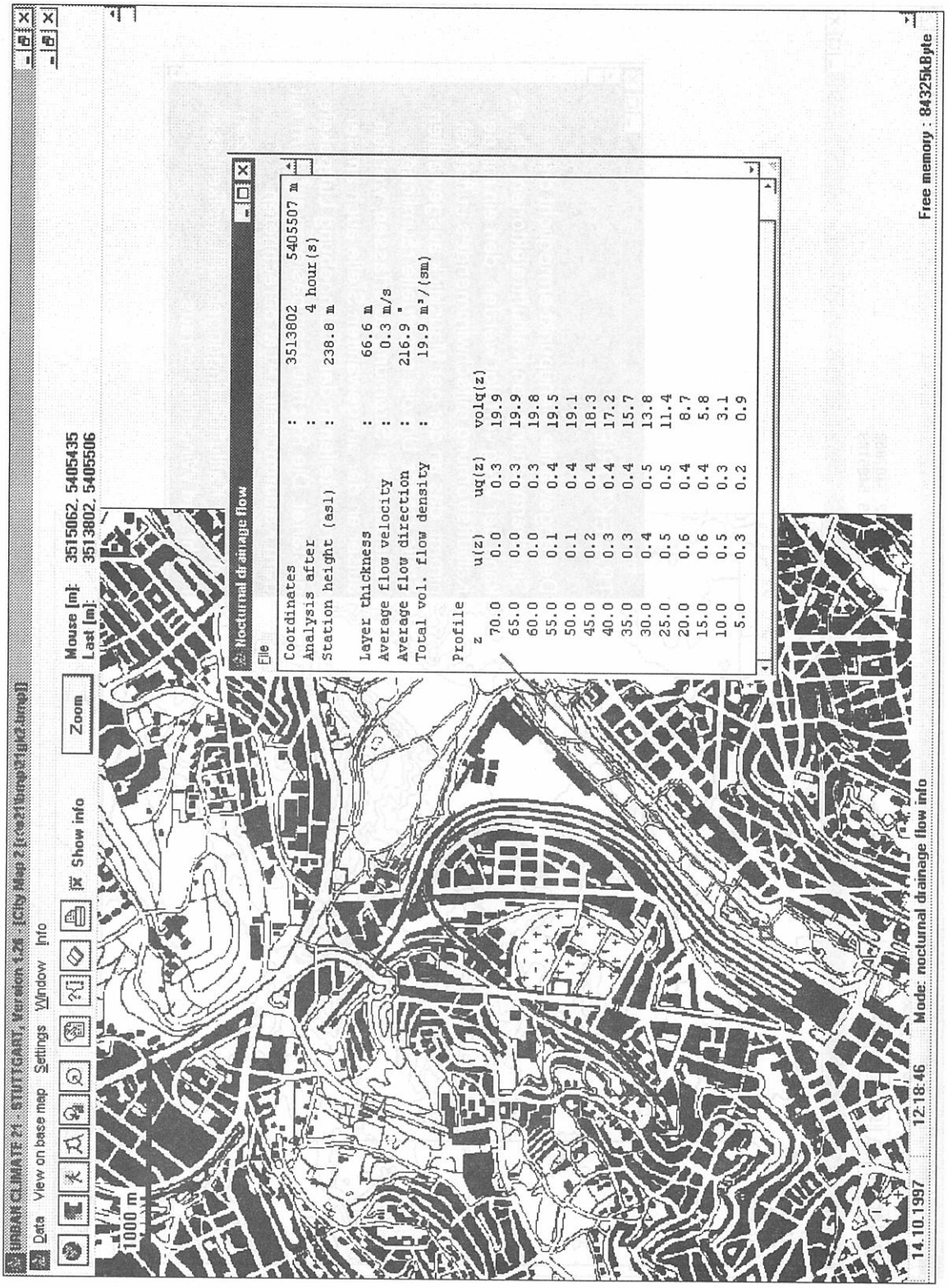

Figure 7 Screenshot: Nocturnal drainage flow information for a special point of Stuttgart

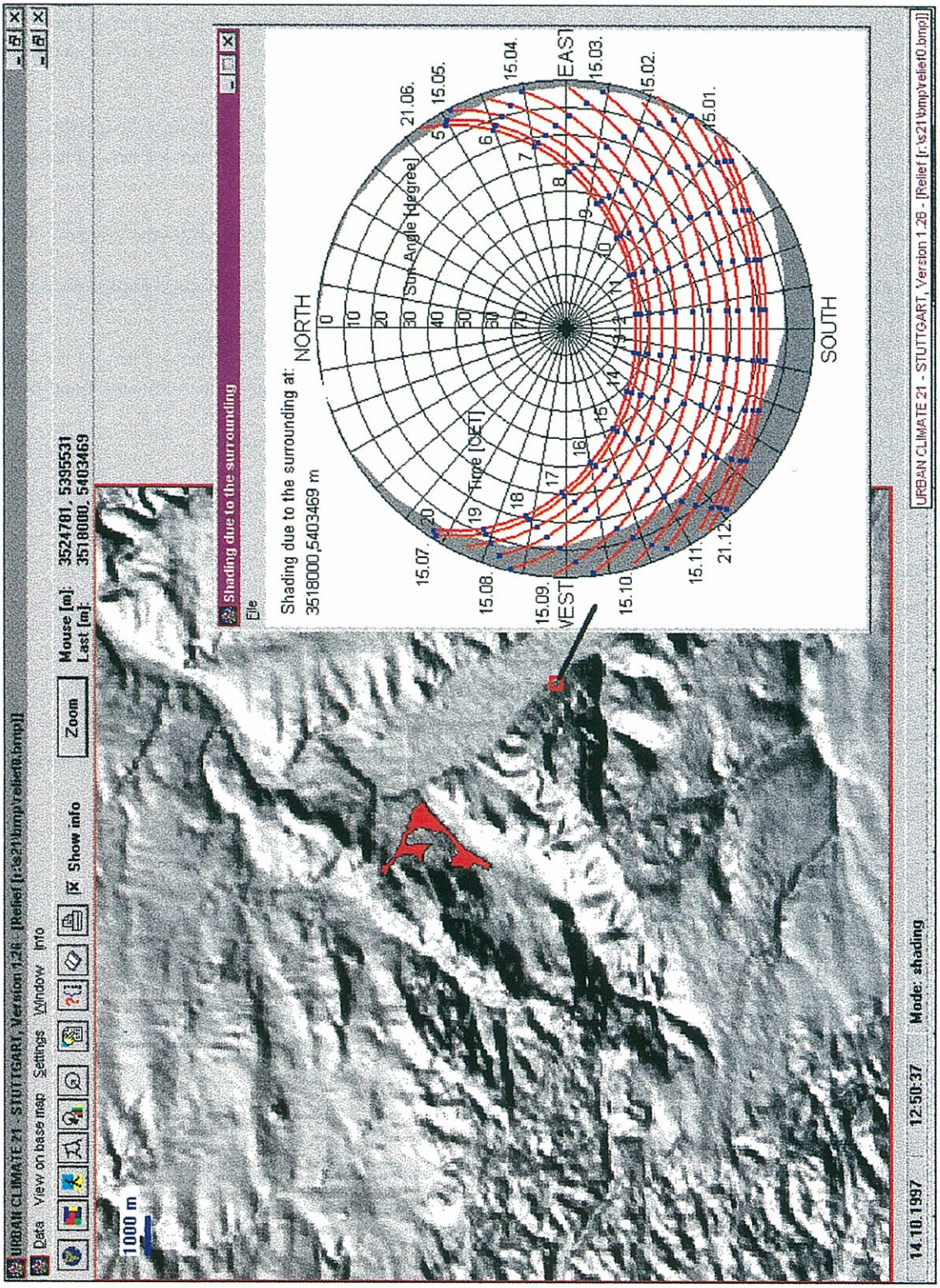

Figure 8 Screenshot: Diagramm of sunshine for a special point in Stuttgart (with shading by relief)

Future developments:

Although version 1.21 (1997) of "Stadtklima 21" already contains many informations, data (350 MB) and possibilities of inquiries, version 2 is projected to be even more powerful. At present we think about the realization of the following points:

- The size of the wind roses, displayed on the background of the maps, is adapted according to the zoom-factor of the maps. In the menue "settings" a global zoom-factor can be set, determining the size of the wind roses on the maps
- Display of rose of wind direction and windvelocity
- Playing of audio (WAV)-files during start of the programm, during slide-shows and during display of bitmaps
- Graphical display of position of the sun, track of the sun and position of topographical features shading the sun
- Introduction of a zoom-factor-feature for the display of BMP- and WMF-files
- Integration of an english version of the programm
- Possibility to export the content of BMP- and WMF-files and the actually choosen map for the background into the windows clipboard
- Display of selected polygons on the maps for the background (f.e. streets)
- Preparation of a glossary
- Display of a calendar showing the climatological parameters of Stuttgart in the course of the year

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