SBORNÍK ČESKOSLOVENSKÉ GEOGRAFICKÉ SPOLEČNOSTI
Ročník 1984 • Číslo 2 • Svazek 89

RUDOLF BRÁZDIL, MIROSLAV KOLÁŘ, PAVEL PROŠEK

THE STUDY OF LOCAL CLIMATOLOGICAL CONDITIONS OF TOWNS

Introduction

Among the chief tasks facing the present climatology belongs above all the solution of prognosing and improving the climate, which ought to aid in solving a complex of problems of the environment of the human society and its energetic, food and ecological problems. These problems, essentially of global character, must be solved on a regional or local scale, i. e. they must gradually become an inseparable component of the landscape research.

This sphere logically includes also the study of the climate in towns as a specific form of local and/or mesoclimatic conditions. Understanding the climate in towns is a problem of an extraordinary social importance. This is above all related with the abrupt growth of the town population throughout the world (in 1900 by 13.6 %, in 1979 already by 39.7 %) and with a striking deterioration of the environment in many large towns. In this context meteorological and climatological conditions are an extraordinarily important factor of the quality of the environment of towns.

In individual cases influencing the meteorological and climatological regime in towns it is very complex and varied, depending on a number of factors, such as the size of the town, the extent and kind of the built-up area, the location and kind of industrial plants, as well as geographical conditions of the town and its immediate surroundings.

Generally, it is possible to classify the effects of these factors as follows:

1. specific physical properties of artificial (urbanized) active surfaces;
2. production of artificial waste heat energy;
3. emission of pollutants into the atmosphere;
4. effects of the polluted town atmosphere on the components of the energetic balance of the system active surface — town atmosphere.

With respect to the time and space variability of the characteristics of the climate conditioned by the above factors measurements in the traditional network of meteorological stations need not yield sufficient starting information about the climate of the town in question. For obtaining a more detailed information it is necessary to coplete these basic measurements by other ways of obtaining data, such as a special station network or ambulant measurements.

The object of the present paper is to show the basic characteristics of local climatological conditions in a town on the example of Brno, in

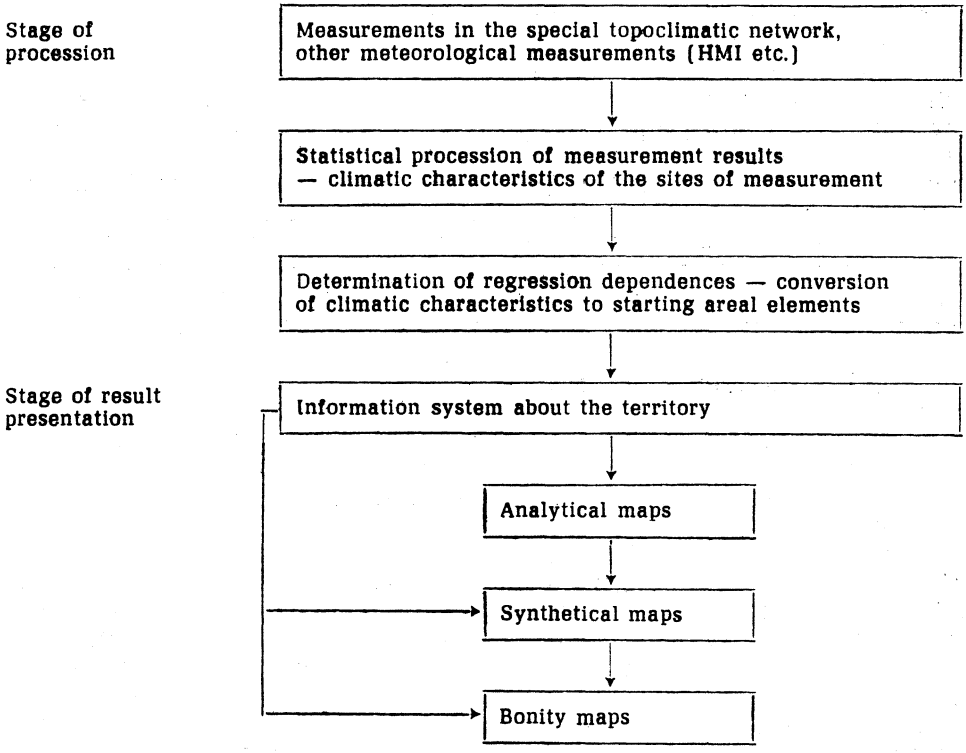
the same way as studies are performed at the Department of Geography, Faculty of Science, J. E. Purkyně University, Brno. The achieved results are a part of a detailed geographical study of the area of the City of Brno.

Metodological approach and procession objects

The methods of acquiring basic information about the climate of a town must necessarily be connected with the general character of the actual urbanized territory and its immediate surroundings.

The City of Brno covers an area of 230.36 km^2, its population on Nov. 1, 1980 was 371,463. The area of the town includes the old quarter (central part) of tenement and family houses, and the newly built-up areas of modern housing estates in its outskirts. 32.7 % of the area of the town is formed by urbanized areas, 39.2 % are utilized by agriculture, and 28.1 % are covered by forests. Extensive industrial production is located partly in the centre, partly along the southern and south-eastern margin of the town.

The area of Brno and its surroundings is formed by a considerably rugged relief. The Dyjskosvratecký úval-graben whose lowest part is formed by the alluvium of the rivers Svitava and Svratka at an altitude



1. Diagram of the method of climatological procession of the town climate.

of about 200 m penetrates the southern and south-eastern parts of the area of the town. In the west, north and east the town is surrounded by hills of the Brněnská vrchovina-highland, reaching the altitude of about 350 to 400 m. Sharply bounded depressions of the basin character occur on the territory of Brno, alternating with conspicuous elevations. The elevations occurring also in the central part of the town are surrounded by a low flat relief.

The study of the town climate in Brno starts from the working diagram (Fig 1), in which two stages are differentiated, the procession and the presentation of results. The first stage includes the problem of the measurements, their procession and the determination of dependences of climatic characteristics on the properties of the active surface.

Stage of procession

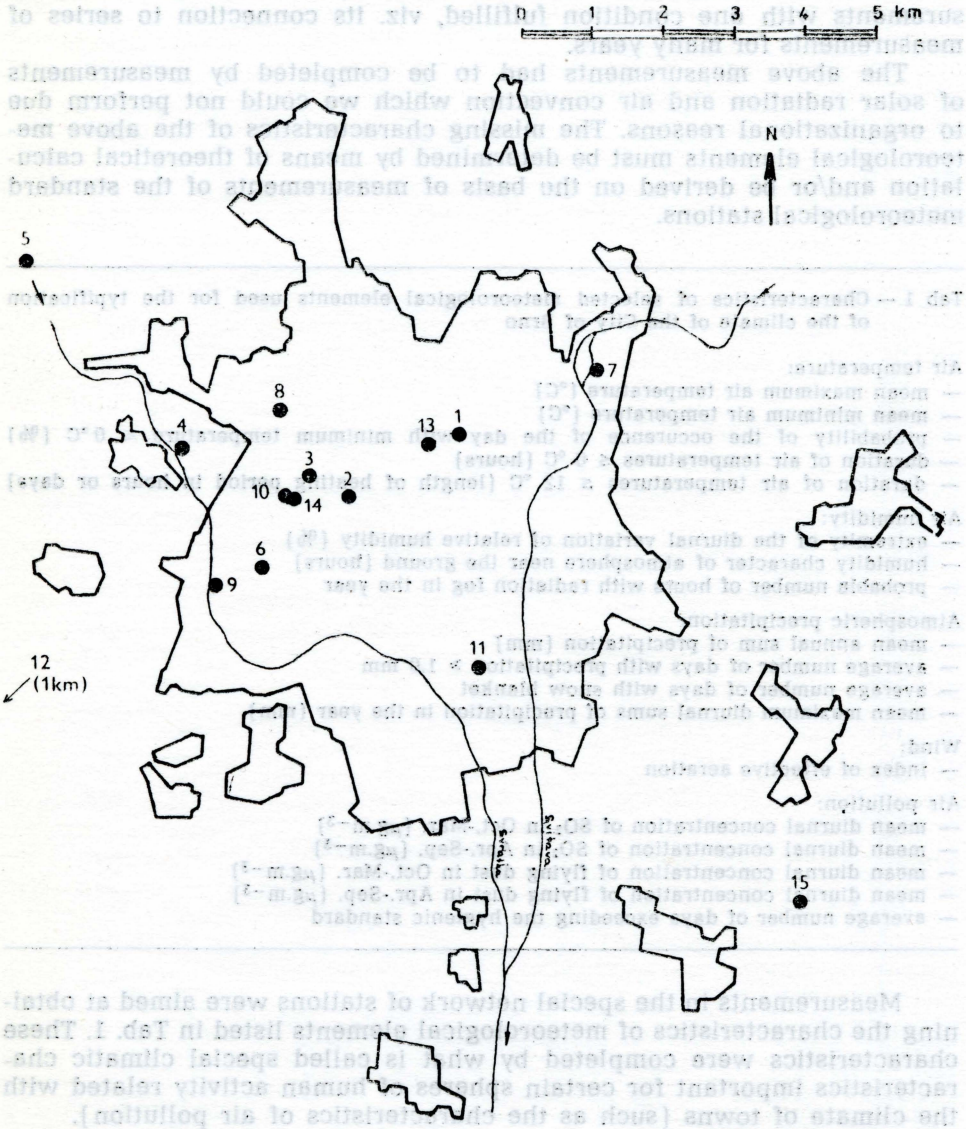
At present two meteorological stations operate on the territory of the City of Brno. Both of them are part of the Hydrometeorological institute (Brno-Tuřany and Brno-Kraví hora-hill, Fig 2), but their location is not typical of the major part of the territory of the town. For detailed information let us mention that on the whole territory of the ČSSR 188 meteorological stations were in operation in 1980, i. e. on an average an area of 419.5 km^2 per one station. This area is comparable to that of large towns in the ČSSR. Data from those stations are, of course, of macroclimatic character and cannot express sufficiently the properties of the climate in towns, particulary in the case of their rugged relief.

With respect to these facts a network of special stations was established on the territory of the town (Fig 2). In locating the stations both the relief morphology and different types of the urbanized surface were taken into account with respect to the maximum surface representation, respecting at the same time, the uniform character of the active surface in their immediate surroundings. The previously mentioned principle was conditioned by the scale of the local climate of the town.

In connection with the fact that at those stations it is — due to personal reasons — impossible to perform measurements in climatic terms (which, by the way, are comparatively inaccurate for obtaining the basic information), the registering apparatus were placed at the stations in meteorological screens (at a height of 1.5 m above the earth surface) (a thermograph and a hygrograph) and the August psychrometer as a controlling device. Once a week record ribbons were changed and twice a week checking measurements were performed. At stations where it was possible to carry out daily measurements rainfall gauges were installed.

In connection with the demand for a minimum lenght of operation of the special station network, which had been verified before in solving other topoclimatic tasks at the Department of Geography, which is one year in maintaining indivisibled seasons of the year (Prošek 1978, Prošek and Brázdil 1981) in the Brno network measurements were carried out for 3 years. A basic unit of processing the climatic characteristics is a day with a radiation regime of weather. It is a day on which the sunshine takes up at least 80 % of the theoretically available time, the wind speed and the shape of the curve of the diurnal variation of air

temperature being taken into consideration. Days with the radiation regime of weather are chosen because they show most conspicuously the effects of the active surface on the physical properties of the atmosphere near the surface and their regime (i. e. the differences among individual parts of the territory under study suppresed in the advection type



2. Diagram of the location of stations in a special station network for studying the climate of the City of Brno: 1. Arboretum, 2. Botanická zahrada, 3. Experiment. botanická zahrada, 4. JZD Komín, 5. Kníničky, 6. Lipová, 7. Maloměřice, 8. náměstí Svornosti, 9. Pisárky, 10. Planetárium, 11. Škrobárny, 12. Troubsko, 13. Zbrojovka, 14. Brno-Kraví hora (HMI), 15. Brno-Tuřany (HMI).

of weather are shown in the most conspicuous form in the radiation type of weather). The above method is applicable in providing temperature and humidity characteristics.

Substantially more complicated is the procession of precipitation, whose relationship to the active surface (chiefly to its morphology) is still more complex. In processing it one must start from long-term measurements in the standard network of stations, or from short-term measurements with one condition fulfilled, viz. its connection to series of measurements for many years.

The above measurements had to be completed by measurements of solar radiation and air convection which we could not perform due to organizational reasons. The missing characteristics of the above meteorological elements must be determined by means of theoretical calculation and/or be derived on the basis of measurements of the standard meteorological stations.

Tab 1 — Characteristics of selected meteorological elements used for the typification of the climate of the City of Brno

Air temperature:
- mean maximum air temperature (°C)
- mean minimum air temperature (°C)
- probability of the occurence of the day with minimum temperature ≤ 0 °C (%)
- duration of air temperatures ≤ 0 °C (hours)
- duration of air temperatures ≤ 12 °C (length of heating period in hours or days)

Air humidity:
- extremity of the diurnal variation of relative humidity (%)
- humidity character of atmosphere near the ground (hours)
- probable number of hours with radiation fog in the year

Atmospheric precipitation:
- mean annual sum of precipitation (mm)
- average number of days with precipitation ≥ 1.0 mm
- average number of days with snow blanket
- mean maximum diurnal sums of precipitation in the year (mm)

Wind:
- index of effective aeration

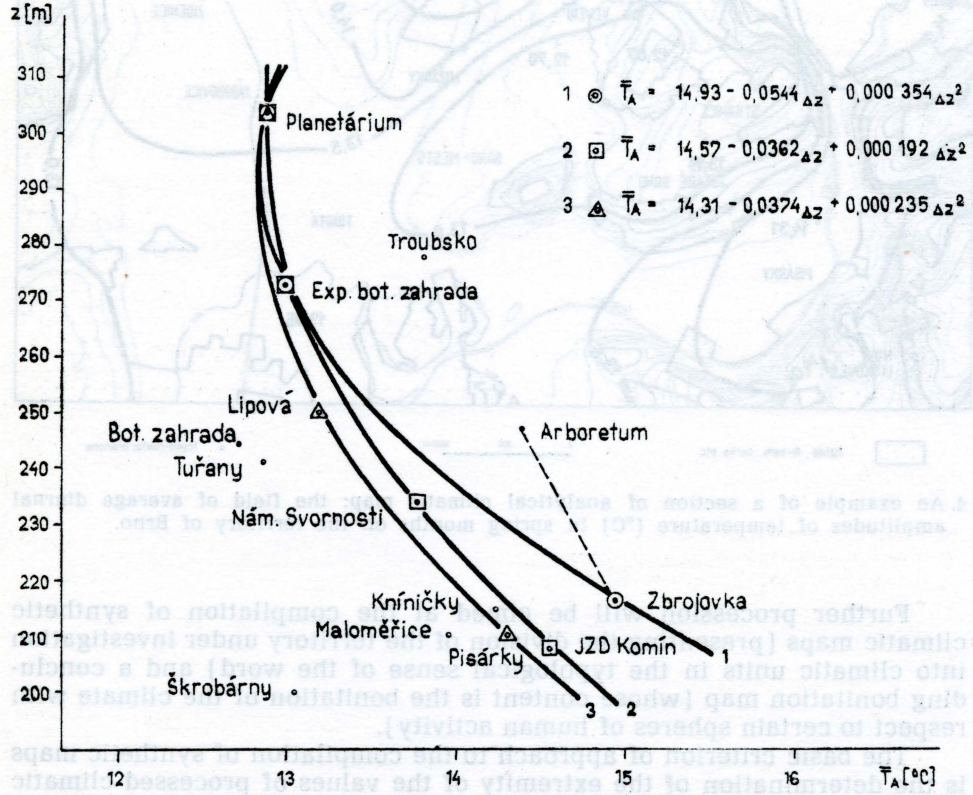
Air pollution:
- mean diurnal concentration of SO_2 in Oct.-Mar. ($\mu g.m^{-3}$)
- mean diurnal concentration of SO_2 in Apr.-Sep. ($\mu g.m^{-3}$)
- mean diurnal concentration of flying dust in Oct.-Mar. ($\mu g.m^{-3}$)
- mean diurnal concentration of flying dust in Apr.-Sep. ($\mu g.m^{-3}$)
- average number of days exceeding the hygienic standard

Measurements in the special network of stations were aimed at obtaining the characteristics of meteorological elements listed in Tab. 1. These characteristics were completed by what is called special climatic characteristics important for certain spheres of human activity related with the climate of towns (such as the characteristics of air pollution).

After calculating the characteristics of meteorological elements in the individual stations it is necessary to solve the problem of extending the validity of these data to the whole territory under study, and/or in individual parts of the area of the information system. For this purpose is used linear or non-linear regression relations between the individual

characteristics and the altitude. Also other parameters must be taken into consideration as well as local peculiarities of the terrain (morphology, exposition and/or different local factors). An example of the application of this method is illustrated in Fig 3.

On the basis of dependences formulated in this way it is possible to proceed to the further stage of procession, i. e. to the presentation of the results in the form of climatic maps.

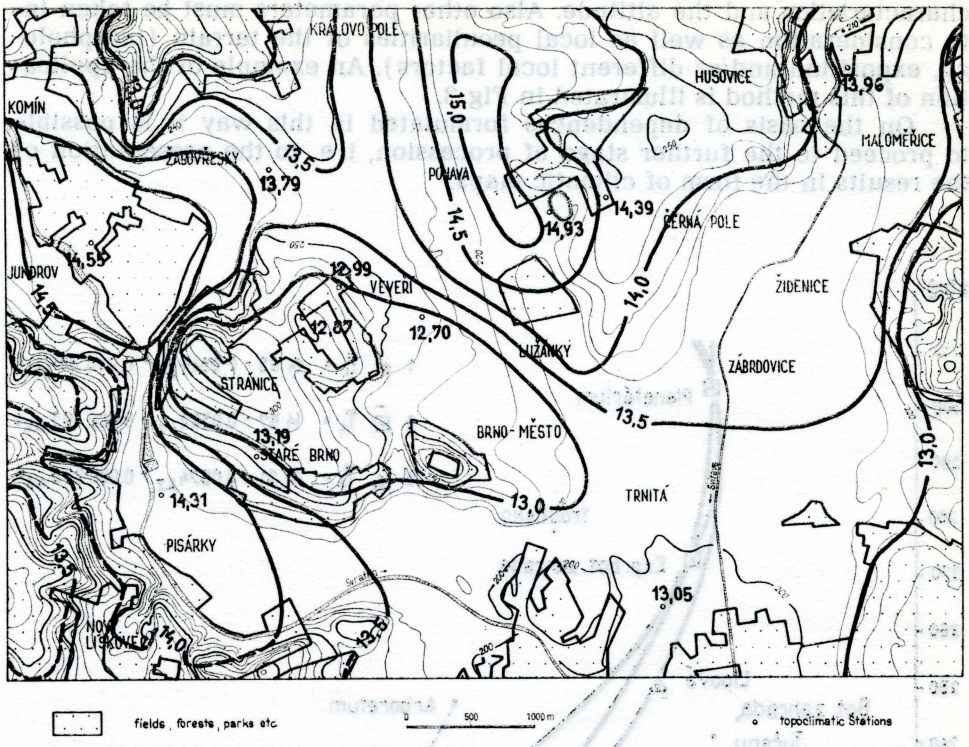


3. An example of regression dependences of the average diurnal amplitude of temperature ($\bar{T}_A$ [°C]) at an altitude in spring months.

The stage of presenting the results

The first type of climatic maps can be considered — from the point of view of J. Paszyński (1980) — the analytical maps picturing the space distribution of the respective characteristics of the selected meteorological elements. An example of such a map is given in Fig 4.

In solving the above task we have reached this stage of map making. Hitherto obtained results are presented in papers by R. Brázdil, M. Kolář and P. Prošek (1983 a, b, c, d).



4. An example of a section of analytical climatic map: the field of average diurnal amplitudes of temperature (°C) in spring months on the territory of Brno.

Further procession will be aimed at the compilation of synthetic climatic maps (presenting the division of the territory under investigation into climatic units in the typological sense of the word) and a concluding bonitation map (whose content is the bonitation of the climate with respect to certain spheres of human activity).

The basic criterion of approach to the compilation of synthetic maps is the determination of the extremity of the values of processed climatic characteristics by means of methods usual in the mathematical statistics [such as the methods used previously by P. Prošek (1978) or by P. Prošek and R. Brázdil (1983)]. In this way we shall avoid a vast spectrum of partial climatic units which would be obtained by the method of mere superposition of the individual analytical maps at the unit interval of isolines.

The compilation of the bonitation climatic map will be solved by means of what is called relative climatic potential which, in the paper by P. Prošek and R. Brázdil (1981) is defined as a criterion of partial portions of the territory studied for different spheres of human activity from the point of view of the climate. The relativity of the potential follows from the fact that it expresses the above disposition only within the territory under investigation; an example of a bonitation map is given in the paper by P. Prošek and R. Brázdil (1983).

Conclusion

The above methods and the way of processing, verified hitherto in studies of the local climate in regions of the countryside type appear — after certain modifications — suitable also for the study of the climate of towns. The results, presented in the form of analytical, synthetical and bonitation maps are a necessary basis for the decisive and controlling activity of designing and planning organizations.

References

BRÁZDIL R., KOLÁŘ M., PROŠEK P. (1983a): Klimaticheskiye issledovaniya zagryazneniya atmosfery v gorode Brno. — Proceedings of the conference Mikroklima a mezoklima městských aglomerací, 13.—16. 6. 1983, in press, Brno.

BRÁZDIL R., KOLÁŘ M., PROŠEK P. (1983b): Pole temperatury vozdukha v masshtabe klimata goroda Brno. — Proceedings of the conference Mikroklima a mezoklima městských aglomerací, 13.—16. 6. 1983, in press, Brno.

BRÁZDIL R., KOLÁŘ M., PROŠEK P. (1983c): Pole vlashnosti vozdukha v masshtabe klimata goroda Brno. — Proceedings of the conference Mikroklima a mezoklima městských aglomerací, 13.—16. 6. 1983, in press, Brno.

BRÁZDIL R., KOLÁŘ M., PROŠEK P. (1983d): Inversii temperatury v oblasti aglomeracii goroda Brno. — Proceedings of the conference Mikroklima a mezoklima městských aglomerací, 13.—16. 6. 1983, in press, Brno.

PASZYŃSKI J. (1980): Metody sporzadania map topoklimatycznych. — Dokumentacja Geograficzna, 3:13—28, Wroclaw — Warszawa — Kraków — Gdańsk.

PROŠEK P. (1978): Vliv reliéfu na teplotní poměry Pavlovských vrchů. — Folia Fac. Sci. Nat. Univ. Purk. Brun., XIX (Geographia 13): 5,99 pp., Brno.

PROŠEK P., BRÁZDIL R. (1981): Klimatologické zpracování atmosférické komponenty krajiny jako součást komplexní fyzickogeografické regionalizace. — Proceedings of 15. sjezd Československé geografické společnosti: 45—50, Brno.

PROŠEK P., BRÁZDIL R. (1983): An example of the climatological processing of the atmospheric landscape component. — Journal of climatology, Vol. 3, 285—295, London.

Shrnutí

STUDIUM LOKÁLNĚ KLIMATOLOGICKÝCH POMĚRŮ MĚST

Mezi hlavní úkoly, stojící před současnou klimatologií, patří především řešení problematiky prognózy a meliorace klimatu, která by měla napomoci při řešení životního prostředí lidské společnosti a jejích energetických, potravinových a ekologických problémů. Tyto problémy, mající ve své podstatě globální povahu, musí být při praktickém řešení směrovány do regionálního či lokálního měřítka. Do této oblasti patří logicky i studium klimatu měst, jako specifické formy místních, resp. mezoklimatických poměrů.

Lokálně klimatologická zpracování, prováděná na katedře geografie přírodovědecké fakulty UJEP v Brně, vycházejí ze schématu, uvedeného na obr. 1.

Nutným výchozím předpokladem pro tyto studie je vybudování účelové sítě topoklimatických stanic, doplňující existující meteorologické stanice, které musí v podmínkách městské aglomerace vystihovat nejen morfologii reliéfu (vrcholové, svahové a údolní polohy), ale i různé typy urbanizovaného povrchu (obr. 2). S ohledem na možnosti přístrojového vybavení by měly být ze sítě získávány informace o charakteristikách hlavních meteorologických prvků, zejména slunečního záření, teploty a vlhkosti vzduchu, proudění, atmosférických srážek a znečištění atmosféry. Délka měření by neměla být kratší než jeden rok. Provoz účelové sítě lze podle možnosti doplňovat různými druhy ambulantních měření. Základní časovou jednotkou pro zpracování klimatických

charakteristik teploty a vlhkosti vzduchu je den s převládajícím radiačním režimem počasí, při kterém se nejvýrazněji projevují rozdíly mezi dílčími částmi studovaného území.

Výsledky měření jsou pro jednotlivé stanice zpracovávány běžnými statistickými metodami a pro zjištěné charakteristiky se určuje jejich závislost na parametrech reliéfu a na ostatních lokálních faktorech a formuluje se pokud možno v podobě příslušných regresních vztahů (obr. 3). Získaných vazeb se využívá k plošnému znázornění zpracovávaných charakteristik ve formě analytických map (obr. 4.). Na jejich základě se sestavují mapy syntetické (mapy topoklimatických typů). Proces tvorby analytických a syntetických map probíhá buď tradičním zpracovatelským postupem, nebo lze získané informace vztažené k výchozím plošným elementům (např. čtverce, šestiúhelníky) zahrnout do informačního systému o studovaném území a s využitím výpočetní techniky získat zmíněné mapy v podobě map počítačových.

V případě zpracování klimatu města Brna byly stanoveny charakteristiky, uvedené v tab. 1.

Další etapou klimatologické analýzy je sestavení bonitačních map. V souvislosti s tím zavádíme tzv. relativní klimatický potenciál, který vyjadřuje dispozice různých částí studovaného území pro rozličné oblasti aktivity člověka z klimatického hlediska. Analytické, syntetické a bonitační mapy jsou nezbytným podkladem pro rozhodovací a řídící činnost projektových a plánovacích organizací.

(Address: Přírodovědecká fakulta Univerzity J. E. Purkyně, Kotlářská 2, 611 37 Brno.)