ACTA UNIVERSITATIS LODZIENSIS
FOLIA GEOGRAPHICA PHYSICA 3, 1998

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PROBLEMS AND METHODS OF MODERN APPLIED CLIMATOLOGY

PROBLEMY I METODY WSPÓŁCZESNEJ KLIMATOLOGII STOSOWANEJ

In this paper the object of the researches, problems of modern applied climatology and new methods of its dissolution are discussed. Some methods of identification, elaboration and using of meteorological information in the technology and other technical domains are presented. The tasks of applied climatology in the sphare of climate estimation from the different points of view are discussed.

Applied climatology is a science which develops special climatic indices to account for the influence of the varying climate on socioeconomic progresses, on nature and person and to account for the reverse influence of these processes on the climate. Its basic task is creation of the specialized climatic information relating to climatic resources, unfavourable climatic actions and also the orientation of an economic activity to application of the climatic standards. Applied climatology has arisen almost simultaneously with the beginning of meteorological observations.

At the present time the new approaches to the content of the applied climatology are outlined. The scientific and technical progress stimulates an active development of separate branches of applied climatology with their specific pecularities such as building and urban climatology, transport, bioclimatology and other branches. Alongside with the use of routine climatic data the emphasis is put on the application of the great diversity of specialised climatic characteristics oriented to the specific customer of the current meteorological data, and on the application of prompt climatic predictions for month, season, year and also on predictions of climatic changes. In modern conditions of the managing it appeared on the one hand a necessity of an evaluation of the risk from unfovourable events and especially of spontaneous meteorological phenomena and catastrophes

and on the other hand to explore climatic resources as the basic for the energy saving and the rise of the quality of the life.

Becoming now the necessity a partial commercialization of climatic activity requires the realisation of marketing researches in the field of applied climatology production and services with the goal of bringing to customers notice the modern achievments in climatology.

Thus, in modern understanding, applied climatology is an independent versatile science having its own methodology of scientific researches. In its framework some scientific directions are selected:

1. Investigation of the impact of the climatological factors on different objects, materials and technological processes in various fields of economics and an elaboration specialized climatic indices.

2. By means of the special probability statistical methods the modern technique of calculations, prediction is developed which takes into account the transformation of specialized climatic indices by the action of local conditions.

3. By means of geographical and physical-statistical methods the theory and methodology of the space extensions of climatic data and representation of these extensions as a reference media, normative documents and the provision of technical projects and business plans.

4. Economical-statistical methods are used for evaluation of socio-economic usefulness of the information on climatic resources and climatic risk. The optimal strategy of its use is developed and the marketing researches are conducted, which are devoted to the analysis of the market customers, competition and to advertising of the climatic information, production and services.

The given system of researches is used in many fields of applied climatology. However in each area the researches are directed towards solution of different problems and this obstacle endows the researches with peculiar features.

The most important problems of the urban climatology are:

1. The establishment of singularities of city climate and microclimate and the evaluation of their correspondence to the general plan of the city and to concept of its development.

2. All climatic resources of the city must be taken into account for the optimization of residing of the urban population and for energy saving.

There are many works devoted to the first problem. The second problem is connected with different scientific branches and for this reason is not sufficiently advanced. Let us stop on it.

The climatic resources of the city are those properties of a climate, which render a favourable action on the potential well-being of the city. Stores of heat, moisture, wind and sun power can be considered as resources. They can be used directly for heating of dwellings, watering of

green plantings and production of an electrical energy. There are also indirect possibilities presented by the city climate. Example of such indirect use of climatic resources is the most favourable orientation of a building relating to the sun and wind.

The special climatic indices of climatic resources of the city are, for example:

1. The number of degreedays which defines necessary stores of fuel for heating a building and at the same time defines the thermal resistance of the construction protecting the building.

2. 80% quantile of a wind velocity, quantiles of an air velocity with various degree of confidence and corresponding quantiles of an enthalpy, which are used in the calculations of protecting constructions and heating, cooling and conditioning systems.

3. Sums of radiation acting on vertical surfaces of various orientation, used to establish an optimal orientation of buildings and in calculations of protecting constructions, stores of fuel, engineering constructions, solar batteries.

4. Annual distributions of hourly values of an air temperature, its moisture content and enthalpies are primarily responsible for succesful calculations of expenditures of heat, cold and moisture needed in the design of heating, cooling and conditioning systems.

In addition many other specialized indices of climatic resources are established.

Basic specilized bioclimatic indices of resources improving the health and recreation of people are some modifications of effective radiation temperatures and characteristics of the person thermal balance.

Some of the above listed indices were worked out long ago, others were developed by the author and his coworkers recently as well as methods to obtain the characteristics of these indices. The quantile indices of wind, temperature, humidity and enthalpy are given for the first time. Quantiles of temperatures of an air t_p (°C) and corresponding quantiles of an enthalpy I_p (I/kg) for $P_t = 8$, 6, 0.8, 0.1% (during the cold period), for $P_t = 99$, 98, 96, 95% (during a warm period), and $P_y = 7.5$, 5.5, 0.1, 0.01% (during a cold period) and $P_y = 98.1$, 97.1, 95.5, 94.6% (during a warm period) were included in a newly created collection of building norms of countries incorporated into the Community of Independent Countries. The values of these quantiles are used in the design of heating, conditioning and ventilation systems in buildings of different assignment from hospitals, plants of different purposes up to agricultural buildings.

These indices are established as a consequence of the analysis of thermal streams through protecting constructions having various heat – shieldings and infiltrations of the air through nongermetic outside protections (A n a p o l s k a j a, G a n d i n 1976; *Stroitielskije normy...*, *Rekomiendacyi...*). A basis for their calculation are the bivariate distributions of temperature – wind and

temperature – relative humidity. From last distribution it is easy to receive bivariate distributions of temperatures of the air and entalpy (K o b y s h e v a 1996). As boundary values of two-dimensional empirical values are not exact it is appropriate beforhand smoothing employing bivariate distribution functions (K o b y s h e v a, G o l b e r g 1990). Most convenient is the us of many-dimensional construction named by the author as Morgenstern-Humbel distribution. They were first who proposed such construction, is of the form:

$$F(X) = (\Pi\ F_j(Xj))\,(\Sigma\alpha_{ij}\ (1 - F_i(X_i) + 1)\ (1 - F_j(X_j) + 1)$$

$F_i(X_i)$, $F_j(X_j)$ – integral functions of partial distributions,
$\alpha_{ij} = 1/4\ r_{ij}\ \delta_i/I_i\ \delta_j/I_j$,
$I_i = / (X - m_i)\ F_i(X)\ f_i(X)\ dx$,
$I_j = / (X - m_j)\ F_j(X)\ f_j(X)\ dx$,
r_{ij} – the coefficients of the pair correlation,
m_i, m_j, δ_i, δ_j – mathematical expectations and mean squredeviations of partial distributions,
$f_i(X)$, $f_j(X)$ – density of partial distribution.

V. E. Nicis and author have developed (N i c i s 1983) a new technique of an introduction of the specialized climatological information substantiating from economical point of view the choice of the conditioning system during a process of its alternative design. For the definition of annual expenditures of heat, cold and moisture data on the recurence of temperature content of moisture and enthalpy are introduced in the equations.

Distributions of these magnitudes according to authors proposal are approximated either by logarithmicaly normal, one-dimensional distribution function or by the composition of an uniform distribution and a normal one (K o b y s h e v a, G o l b e r g 1990). As examples in Figs. 1–3 quantile characteristics of Leningrad area are presented.

The examples of characteristics of climatic resources of St. Peterburg and the standart building at St. Peterburg are given in Figs. 4–7.

From examples on St. Peterburg some practical conclusions follow. So the distribution of fuel should not be uniform throughout the city. Outskirts of St. Peterburg require more intensive heating. A greater number of degreedays and larger velocities of a wind favours this conclusion. The thermal resistance of protecting constructions also owes to be increased in the direction from the center though to a smaller extent. It is necessary to take into account for each building the amount of solar radiation available during the light part of a day when planning a day-to-day supply of heat. Per spring months, as indicated in the Fig. 8 the energy receips from the sun are very important. For a selected building the saving of an energy per one year makes more than 150 gectocalories.

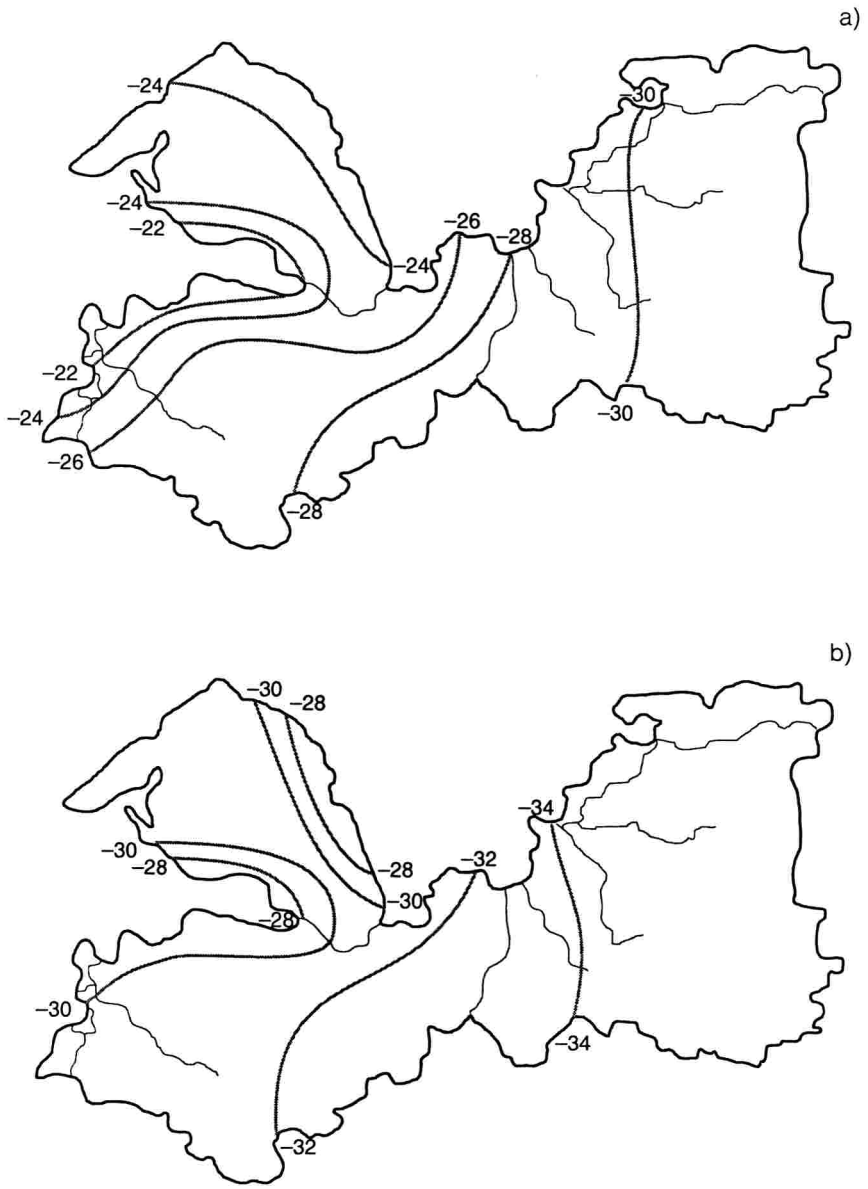


Fig. 1. Calculated air temperature during the cold period: a – with a degree of confidence 0.5% or the temperature of the coldest five days period with a 92% degree of confidence, b – with a degree of confidence 0.1% or the temperature of the coldest five days period with a 98% degree of confidence

Rys. 1. Temperatura powietrza obliczona dla okresu chłodnego: a – na poziomie ufności 0,5% lub temperatura pięciu najchłodniejszych dni na poziomie ufności 92%, b – na poziomie ufności 0,1% lub temperatura pięciu najchłodniejszych dni na poziomie ufności 98%

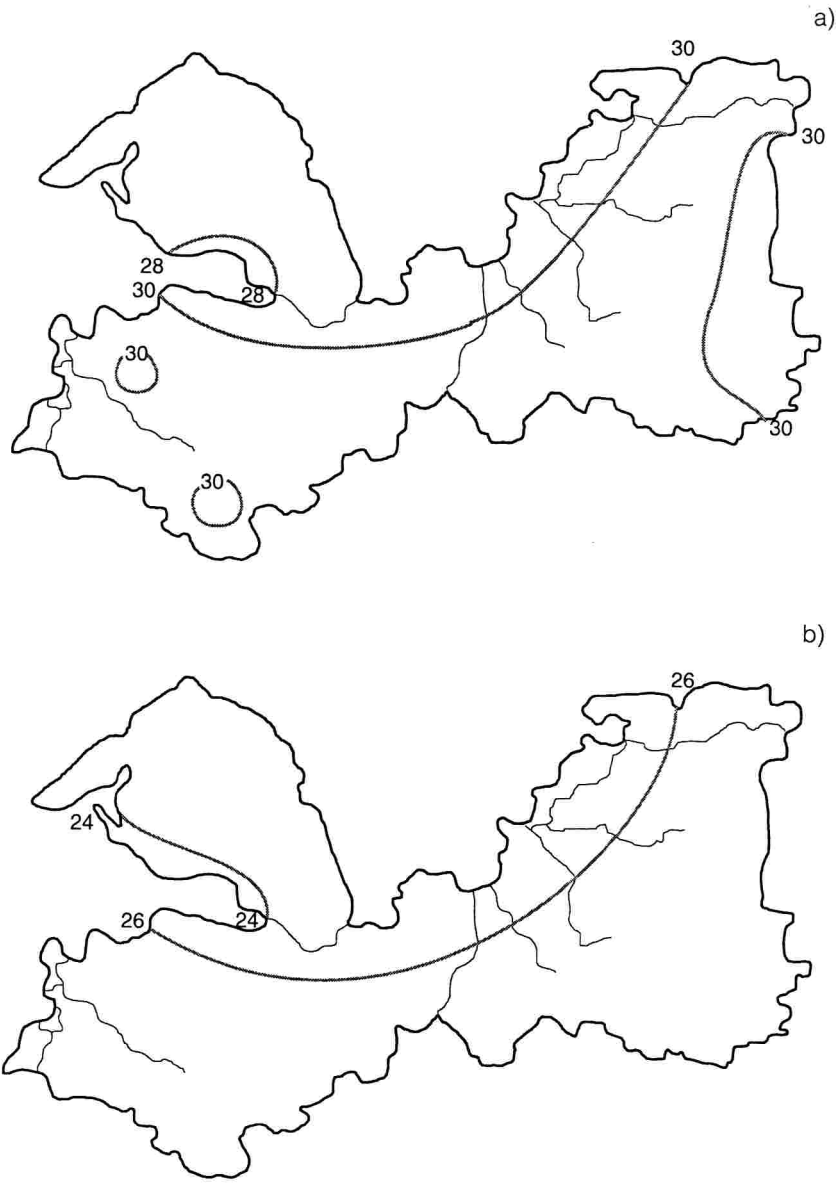


Fig. 2. Calculated air temperature during the warm period: a – with a 99% degree of confidence, b – with a 98% degree of confidence

Rys. 2. Temperatura powietrza obliczona dla okresu ciepłego: a – na poziomie ufności 99%, b – na poziomie ufności 99%

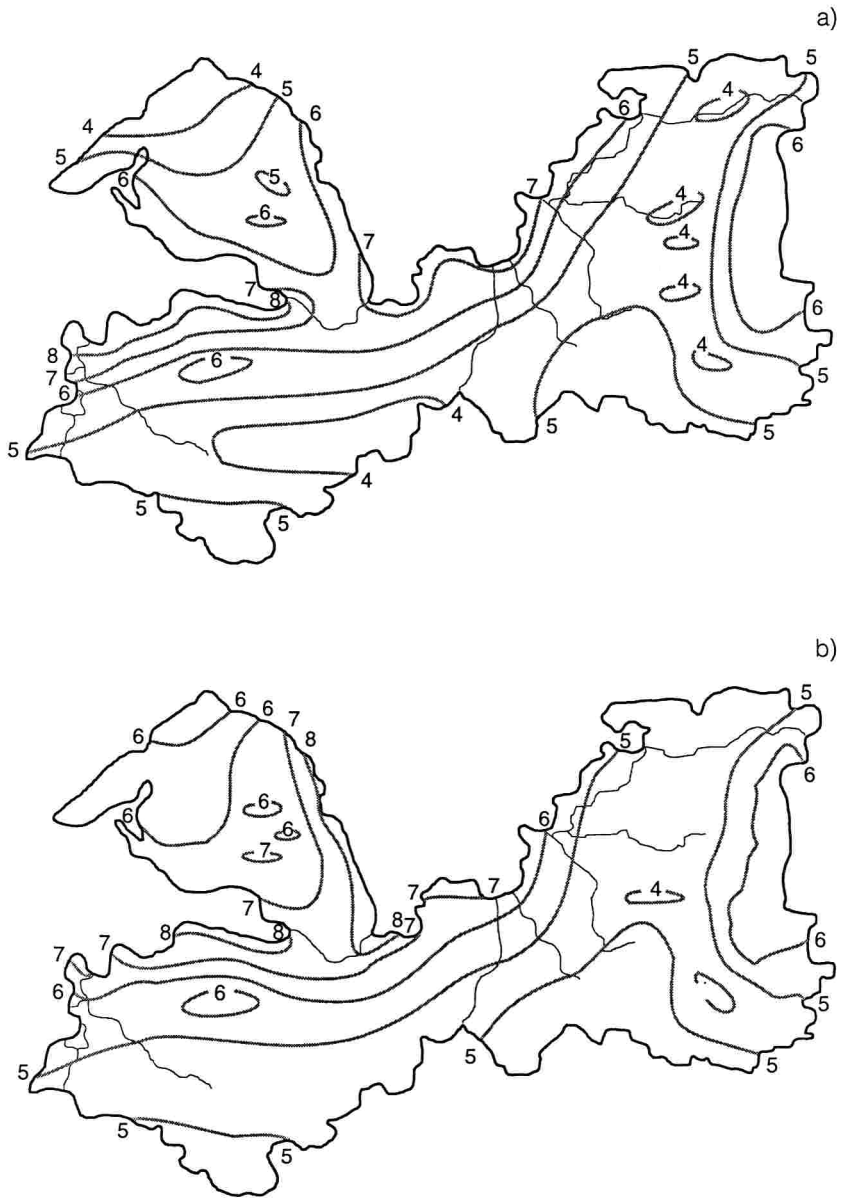


Fig. 3. Velocities of north (a) and north-east winds (b) with 80% degree of confidence over the heating period

Rys. 3. Prędkości wiatrów północnych (a) i północno-wschodnich (b) na poziomie ufności 80% w sezonie grzewczym

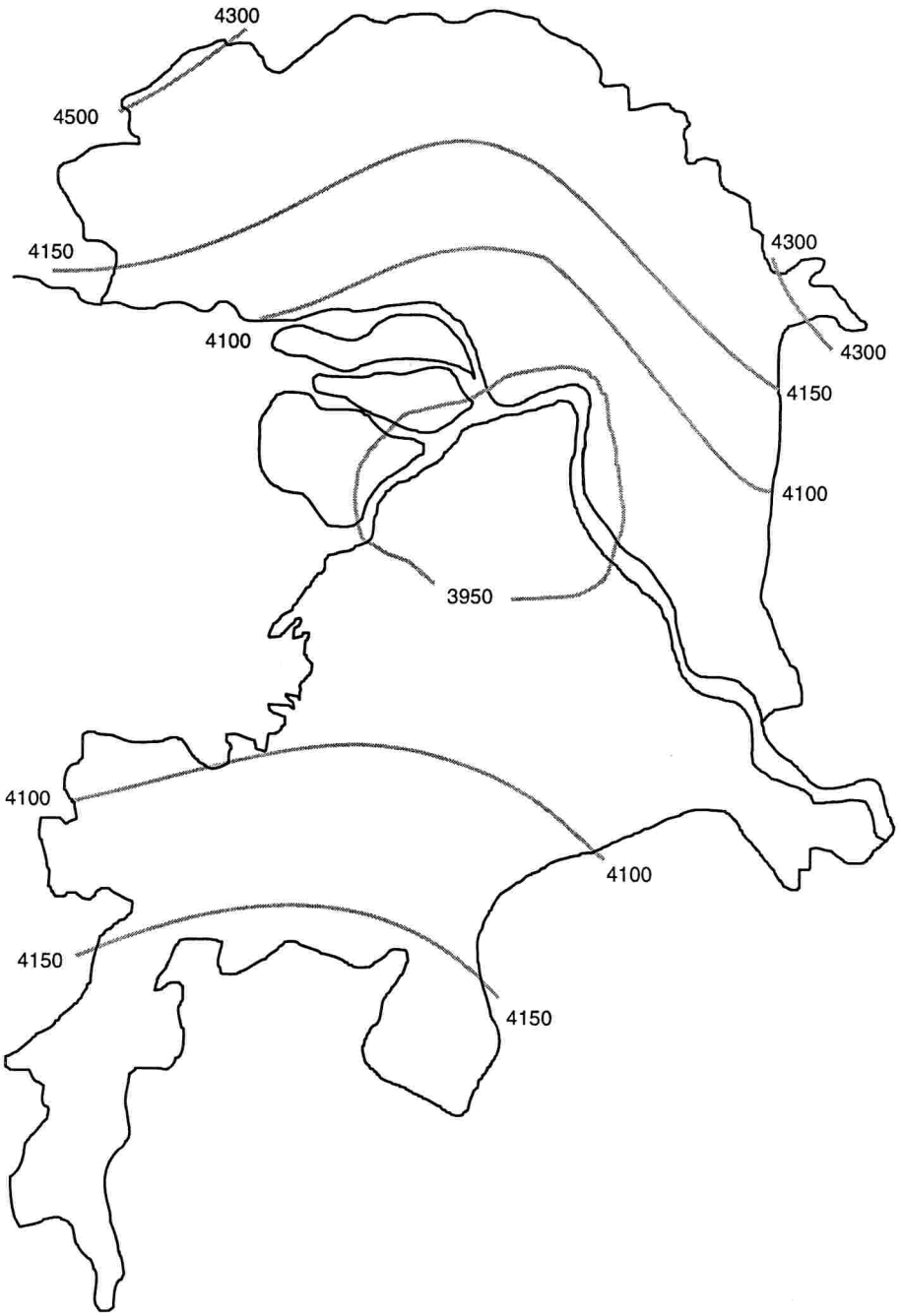


Fig. 4. An average number of degreedays during the heating period

Rys. 4. Średnia liczba stopniodni w sezonie grzewczym

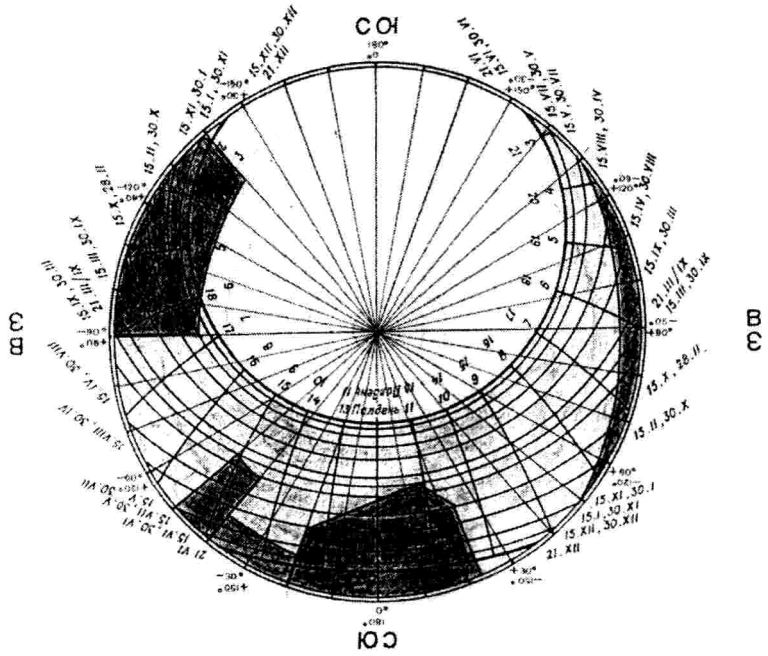


Fig. 5. Shading mask over sunpath diagram

Rys. 5. Stopień przesłonięcia horyzontu na tle ścieżki Słońca

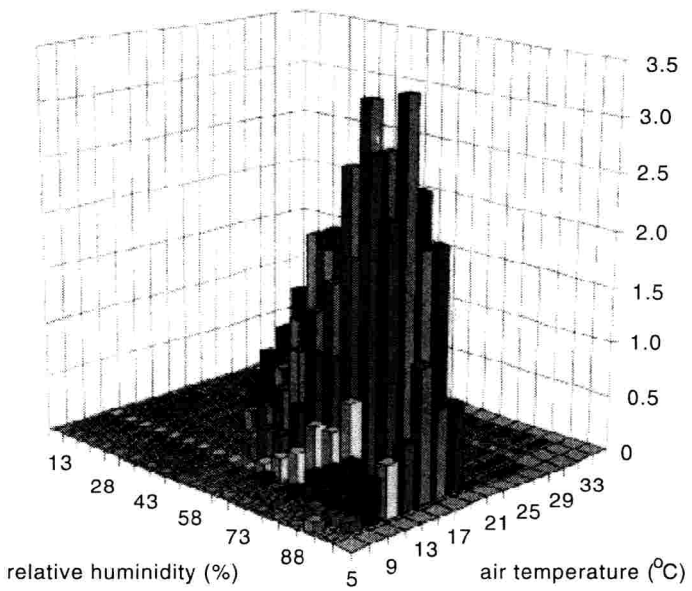


Fig. 6. Bivariate distributions of temperature and relative humidity, July

Rys. 6. Rozkład dwuwymiarowy temperatury i wilgotności względnej, lipiec

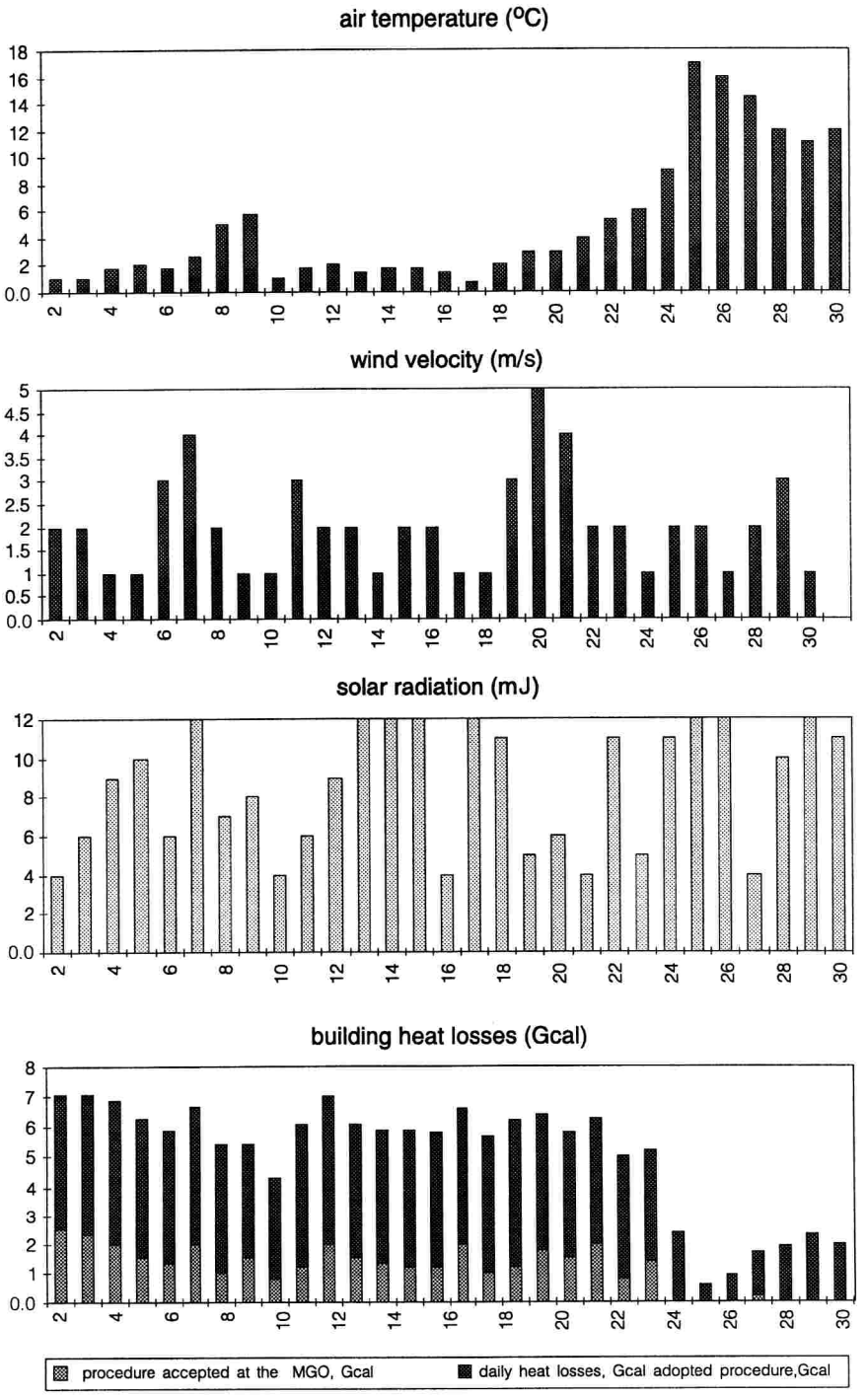


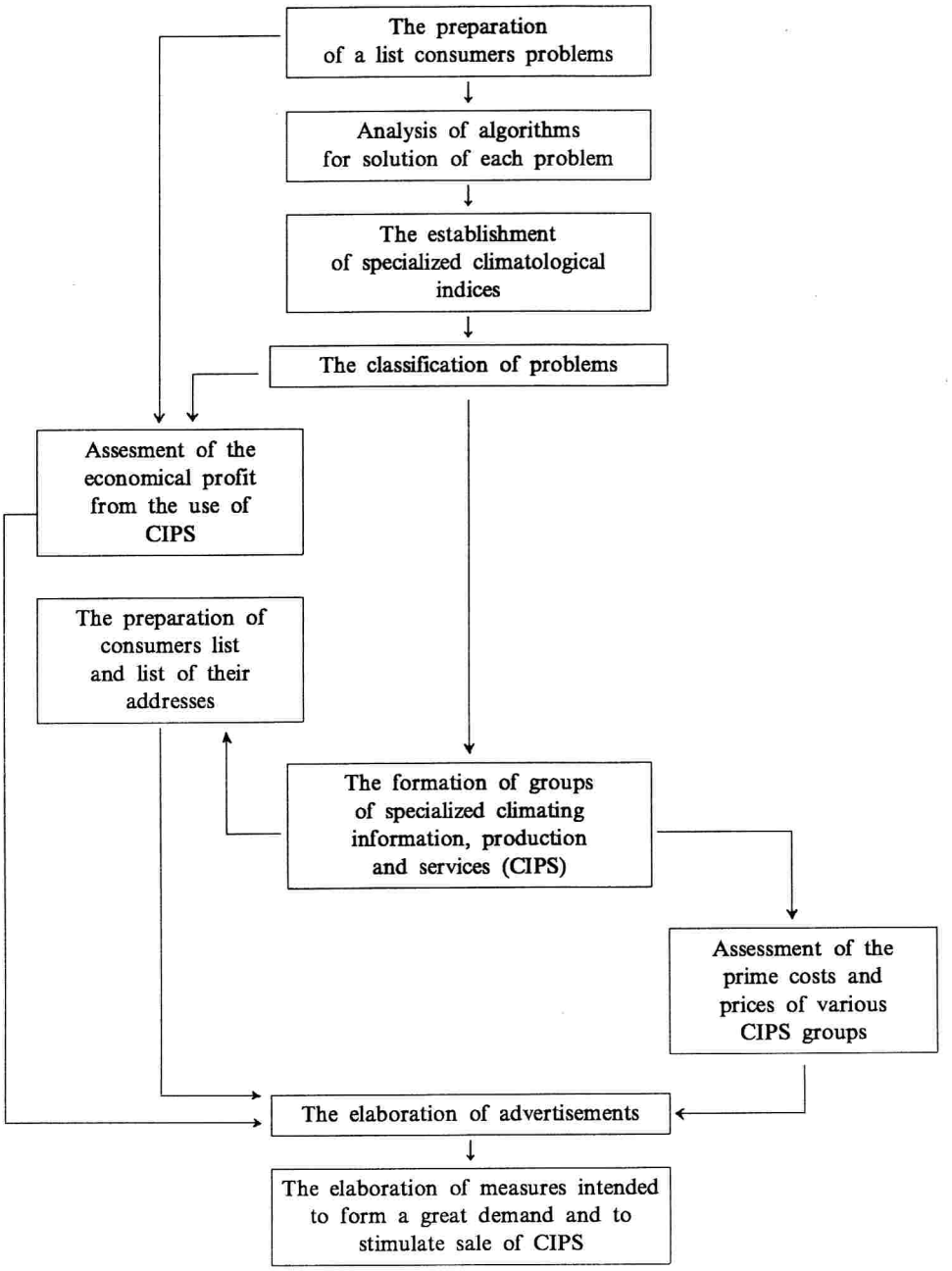
Fig. 7. Combined graphs of a trend of meteorological quantities and building heat losses, April

Rys. 7. Wykresy łączone trendu elementów meteorologicznych i strat ciepła przez budynki, kwiecień

Scheme 1

Pattern of marketing researches realization

Schemat realizacji badań marketingowych



Heating period as show accounts for St. Peterburg and Leningrad area for last 20 years was reduced approximately by 10 days. This obstacle also allows to receive significant saving of money, since one heating day for Leningrad area costs 400 millions of roubles.

The saving of resources and energy can be considerably more if it will be possible to convince customers of necessity of wider use of climatic production. This can be helped by development of marketing researches.

Examples of investigations in this line and also examples of advertising may be found in (Kobysheva, Vimberg 1995).

The resource approach to a climatic information, an evaluation of economic benefits and the development of marketing researches will allow to improve the maintenance of customers.

REFERENCES

Anapolskaja L. E., Gandin L. S., 1976, *Tieplovoj režim zdanij*, Gidrometeoizdat

Kobysheva N. V., 1996, *Use of Climatic Information in the Socio-Economic Design*, [in:] *European Conference on Applied Climatology, 7–10 May, 1996, Norrcoking, Sweden*, p. 185–186

Kobysheva N. V., Golberg M. A., 1990, *Metodičeskije ukazanija po statističeskoj obrabotkie meteorologičeskih rjadov*, Gidrometeoizdat

Kobysheva N. V., Vimberg G. P., 1995, *Marketingovyje issledovanija v sferie klimatologičeskogo obespečenija otraslej ekonomiki primienitelno k informacionnym vozmožnostiam*, [in:] *SPB, Mieždunarodnyj simpozium „Novyje tendencii v gidrometeorologii"*

Nicis V. E., 1983, *Ispolzovanije klimatičeskoj informacii pri projektirovanii sistem kondicionirovanija vozduha*, Trudy GGO im. A. I. Vojejkova

Rekomendacyi po rasčotu infiltracyi naružnogo vozduha v odnoetažnyje proizvodstviennyje zdanija, 1981, M. Gosstroj, Gidroprojekt M.

Stroitielskije normy i pravila, Tieplotiehnika

Department of Applied Climatology
Main Geophysical Observatory, St. Petersburg, Russia

STRESZCZENIE

W artykule omówiono przedmiot badań i współczesne problemy klimatologii stosowanej oraz nowe metody ich rozwiązywania. Przedstawiono metody identyfikacji, opracowania i wykorzystania informacji meteorologicznych w technologii i innych dziedzinach technicznych. Omówiono zadania klimatologii stosowanej w dziedzinie oceny klimatu z różnych punktów widzenia.