POSSIBILITIES OF ENVIRONMENTAL DATA INTERPRETATION IN GROUNDWORK WITH ELEMENTARY GEOMETRIC FIELDS; AN EXAMPLE OF PRECIPITATION

Joanna Bac–Bronowicz

Agricultural University of Wrocław, Department of Geodesy and Photogrammetry
ul. Grunwaldzka 53, 50–357 Wrocław, Poland
phone/fax (+48 71) 3205617, e–mail: bac–bronowicz@kgf.ar.wroc.pl
http://www.geo.ar.wroc.pl/SKP/

Abstract

Recently in Poland there have been numerous changes in properly ownership relations and there is close perspective of joining the European Community. That's why there is the need to construct groundwork of climatic data. They are necessary to make proper decisions in various economic ventures as well as have practical implementation in pro-environmental policy. Creation of such groundwork requires careful investigation, which takes into account influence of the number of climatic factors on the possibilities of land transformation.

We know more and more about the climate on the Earth but simple mechanisms are not sufficient to transform punctual information into continuous information and to ascribe adequate attributes to elementary fields in spatial information groundwork. In this study extension of the method of linear interpolation with regard to terrain configuration and altitude differentiation is proposed. To achieve this the still existing physiogeographic regionalisations configured on the maps were used. Accessible cartographic materials enable to use information of the indices of terrain roughness (dependent on the growth of vegetation, building development etc.) which together with wind conditions determine temperature and precipitation distribution.

This study proposes collection of climatic information from survey stations and after further analysis of distribution the division of the land around the station into the regions of homogenous climatic conditions. Incidence of ground-frosts, hails, torrential rains and floods should also be analysed.

Thus the same information will be ascribed to the elementary fields of climatic groundwork which are equivalents of homogenous climatic regions with certain degree of climatological risk.

Reliability of the parameters will be dependent on taking into consideration suitably long periods of observation. Changes in localisation of survey stations and comparability of different time compartments should also be taken into account, because in synthetic studies precipitation data were interpreted in different manner and originated from different periods.

1. CLIMATE AND GIS

Recently, there has been a lot of research undertaken all over the world devoted to problems of human environment and possible consequences of natural conditions' changes (Geng et al., 1986, Lee et al., 1993). There has been developed certain methods of acquiring, processing, storing, analysing, modelling and sharing of data, which describe natural environment. On the basis of those methods and techniques there has been created geographic information systems and moreover a new discipline – geomatics.

Since 1989 there has been developing rapidly spatial information in Poland (Gazdzicki, 1998), which soon became basic instrument in many research disciplines. In the year 2000 there was presented, elaborated for ten years, an idea of spatial information system (Linsenbarth, 2000). The main base of terrain information systems will include mostly topographic elements and data of terrain elements' functions. Next in succession the base will be supplemented with natural conditions' elements, such as: land and soil use structure, geology, numeric terrain model, morphology and climate. Data concerning above-mentioned elements (except for climate (Bac-Bronowicz, 2000) can be obtained with sufficient accuracy, from specially processed and up-to-date cartographic data and teledetection elaborations.

In the near future there might become necessary to elaborate a method to determine the arrangement of climate elements, such as precipitation and temperature outside meteorological stations in every basic unit of the system. The main goal will be to work out such model of climatic regionalisation (on the grounds of basic data from climatic stations) that one could attribute climatic data to every unit with certain probability.

Current needs of users require correct and more precise interpretation of annual mean values with certain risk rate in larger scales. They enable unbiased assessments of climate condition within smaller units. There have been started several researches on developing climatic data bases in medium scales (Maidment, 1993, Quitt, 1992, Wilson et al., 1996). Since 2000 there has been started COST 719 (http://www.knmi.nl/samenw/cost719) programme for developing a GIS for climate. Methodology of climatic bases utilisation in national spatial information systems and linking them with topographic bases is still under development.

2. THE IMPORTANCE OF POINT DATA'S RELIANCE IN GIS MODELLING OF PRECIPITATION AS AN EXAMPLE OF ENVIRONMENTAL PHENOMENON

Climate for the sake of its spatial variability and output point information which is hard to interpret doesn't have elaboration of spatial information system type on the level of topoclimate in Poland (Obrebska-Starkel, 1996).

At the construction of a model of spatial arrangement of basic climate elements one should take into consideration their dependence on the terrain profile and altitude, which together with wind conditions shape precipitation and temperature. Polish network of measuring stations does not represent most of units which were separated by topoclimatic conditions and therefore commonly used interpolation functions does not meet conditions of good climatic modelling. Reliability of climatic parameter for certain units are also connected with adopting adequately long measuring periods, their representation level, variation range and time step.

2.1 Accuracy of determination points placement

Determining the placement of survey points is a very important element of the preliminary phase of the research. Depending on the type of possessed information it is possible to specify points' position through localising an object by co-ordinates, localising from descriptive information in relation to other topographic objects or localising on the basis of other cartographic information. During absolute height input not only different co-ordinate system, but also reference ellipsoid should be given attention to. Despite compatible geographic reference systems in data linking from two neighbouring countries, there can be a difference in the reverence level. For example Czech stations have different datum level, so any analysis of parameter change connected with the absolute height require recalculation of height.

2. 2 Representation level of the place of the survey

Surroundings of a survey point has got a great influence on the value of measured characteristic, especially in environmental research where attributes are depending on external conditions. Phenomena connected with the climate depend highly on the relief and absolute height.

Precipitation has got a low variation rate within lowland. Values of parameters can vary violently in places of high land variability, especially where morphological barriers are present. Common obstacles for the airflow are river valleys, elevations and mountain ridges. For example in Wrocław (around 300 sq. km.) it is not surprising to find specific parts of the city where changeable weather conditions occur. Rivers and high building in the city centre are sufficient barriers that model uneven distribution.

Specific topoclimate (river valley, clearing, slope with certain exposition) is created under the influence of the closest surroundings of survey point (building, type of the vegetation, relief). Location of the measuring station also can highly influence survey results, for example depending if it is northern or southern slope. Placing a station in every unit separated by topogeographic conditions would be the optimal solution to the problem, that current grid does not meet those requirements. Conditions of the roughness of the neighbourhood, conditions of the transformation of moving air masses, the frequency of calms and light winds etc. should be taken into account during the analysis of the representation level of the station's location. Stations should be placed, where technical and environmental conditions are steady. Information about features of the terrain represented by the specific station are placed in reports. There are several different types of them: plain, seaside-plain, plain and lakes, wide river valley, valley slope, hills, steep slope at a lake, hills and lakes, slope of the plateau, foothills, plateau, large clearing. It means, that certain measured values are valid only for the same landscape unit and further "spreading out of information" should be conditioned by the analysis of the surroundings. Shape of the terrain where station is placed whether convex or concave has also a great influence on the data.

2.3 Stability of the survey point's placement

The change of the measuring point's location can change the conditions of the observation. If measured parameter is so variable with the altitude as precipitation, the change of the altitude of the measuring station during the survey period can alter the value in the data base. Stations are moved because of many different reasons. In Bielawa or Kłodzko station often changed its location, but the method of parameter value correction is known for those points. Nevertheless information about the change of the measuring point's location should be noted in the data base. Changes of the surroundings that occur in time should (construction of new buildings, growth of trees, etc.) also be taken into consideration.

3. CLIMATE INFORMATION REFERENCE UNITS

Selection of the reference unit, which is accommodated to needs, details' level and accuracy of the compilation scale, is a very important point of the construction of the spatial information system for the climate. Bases with geometric enumeration units are used most often. In Poland one of the basic systems is TEMKART (Podlacha, 1999). Initial unit is a trapezium with sides that equals one degree in geographic reference system, divided into fields with sides 10' and 5'. Then the field is divided into 18 rows and 24 columns. It is possible to divide further using quadruple system. At regionalisations another popular unit is a commune (Krzywicka-Blum et al. 1997).

Taking physiogeographic units (Kondracki, 2000) with borders coming from the shape and morphology of terrain raises, from the natural point of view, the probability of determining the correct distribution of climatic phenomena. Those areas are similar taking into consideration the relief, slope, exposition, altitude, geomorphologic structure, etc. On the grounds of this it is possible to distinguish morphological barriers, which are the main factor of climatic characteristics' distribution. A number of features has got a meaningful impact on the distribution of climatic characteristics, and they influence also the placement of borders of physiogeographic units. Adopting those units as basic ones in climatic modelling raises the liability of received results. The size of the areas determines the scale of the accuracy of elaborated climatic regions.

Such a way of climatic factors' distribution, on the grounds of point data could be more reliable information than information taken from beforehand accepted distribution model interpolated in geometrical basic units (GRID – square map grid, TNT – triangular map grid or TEMKART).

Dense network of measuring stations is required especially in mountains and hills, because of very strong influence of relief. Also localisation on a northern or southern slope influences measured parameters. The best solution is to place a station in each unit separated by different topographic conditions, so as to make the data representative for the whole area. Existing network does not meet those conditions. In studies of climate we have to base on the existing data.

4. TRANSFER OF CLIMATIC DATA TO SPATIAL INFORMATION SYSTEM

The importance of careful selection and verification of presented data comes from foregoing analysis. Inaccuracy of information might lead to the construction of untrustworthy phenomena course's model. Accuracy of data gained from the model, which was constructed on the grounds of data base of spatial information system will also depend on the type and size of the reference unit (natural or geometric).

After elaborating areas with similar features of climatic elements' distribution it is possible to transfer information into geometric fields in particular region. Value of the climatic feature or a type of multi-feature distribution of elements should be characterised in each unit with specific probability. Geometric basic units of the system can be aggregated in adequate areas on the grounds of their affiliation to certain climatic regions. Such areas will have similar climatic, morphologic and hydrographical conditions. They can be also a basis for the analysis of distribution of other environment-dependant phenomena, such as different types of pollution or soil erosion. Presented classification can serve to evaluate the usability of areas for different purposes, forecasting the outcome of investments and many other.

Interpolation will be the last stage of the modelling. Final construction of the spatial model will depend on the accepted collection of interpolation criteria (Yang et al. 2000). Depending on the interpolation method (two-stage – distance-weighted and correlational; surface-raster; propagance) the outcome may vary. The results of environmental conditions value interpolation between basic points require consideration about the character of the terrain and its relief. Corrections of isolines, regions borders and reliability zones are introduced as a part of geographic interpolation. As a result, finding regional similarities and determining the borders has a strong biased character and the final result depends on the analysis of as much accessible information as possible that concern the influence of physiogeographic conditions on provisionally described values.

From hydrological point of view differences in the course of isohyets may cause significant differences in the calculation of mean precipitation for given areas.
These facts should be especially emphasised now, when National System of Spatial Information is created. Defining the climatic conditions on the basis of available data for such small units of reference as proposed (1 square kilometre and further divisions into the smaller units) may prove to be a risky task (Fig.1).

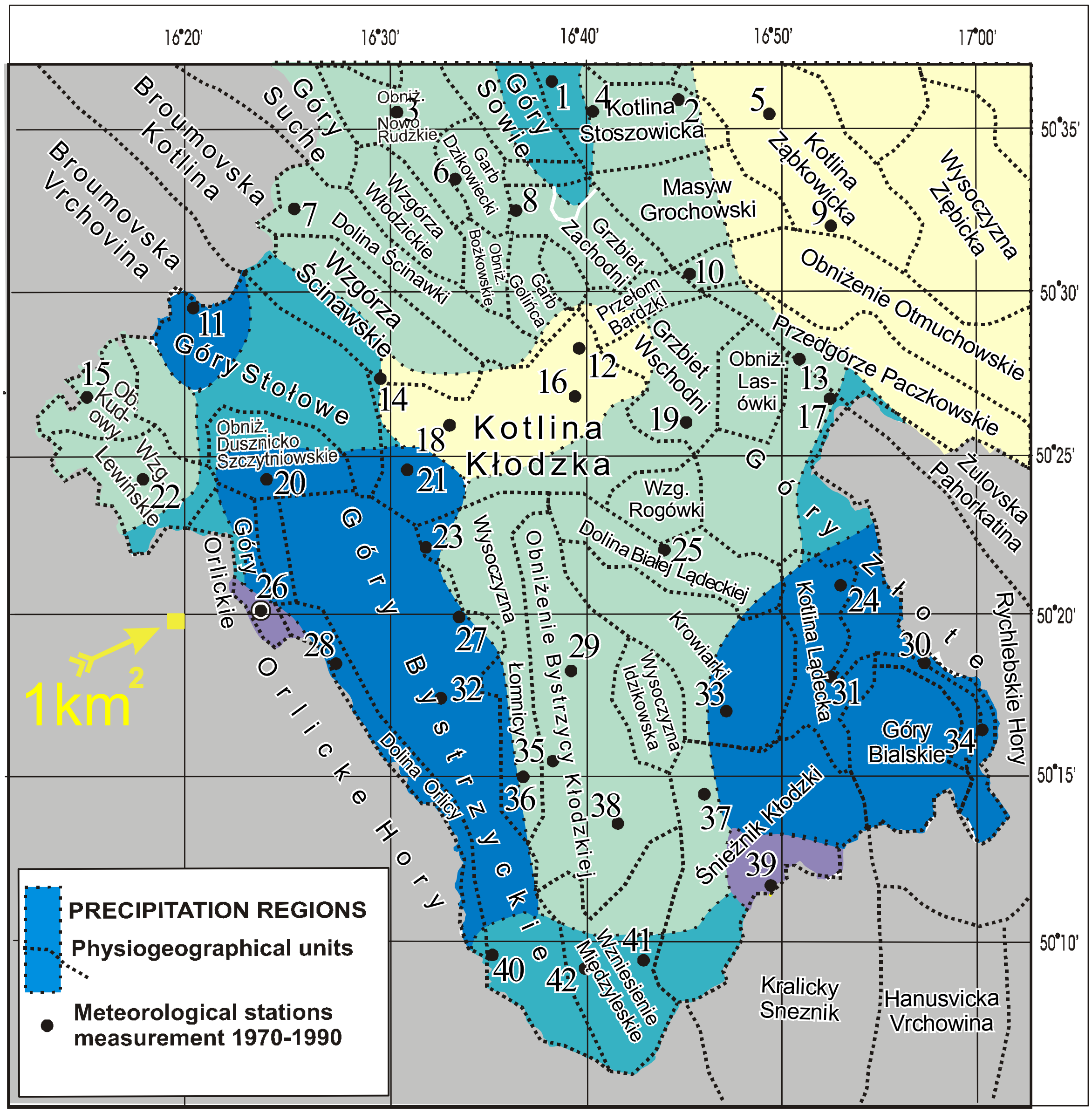

Fig. 1 Map of the spatial arrangement of meteorological stations in Kotlina Kłodzka (Poland). The borderlines of climatic regions based on regionalisation of precipitation

Topoclimatic data is vital for the elaboration of the national and regional spatial information system. On this level data is needed for analyses in GIS to estimate the range and spatial modelling of environmental phenomena. Climate plays a great role in researches on and modelling of: erosion, hydrology, forecasting of changes in land utilisation, forecasting of crops, planning of the land utilisation structure that meet balanced development conditions, evaluating the suitability for different purposes, flood and drought threat, the impact of investments on environment, safety and health of population, preservation of the quality of subterranean water, elaborating environmental valorisation, etc.

REFERENCES:

Bac-Bronowicz J. 2000: *The problem of determination of the boundary line for climatological regions in Lower Silesia*, Prace Geograficzne IGUJ z. 107, Kraków

Gaździcki J. 1998: *Niektóre aspekty rozwoju systemów informacji przestrzennej w Polsce.* Mat. VIII Konf. NT „Systemy Informacji Przestrzennej", Warszawa.

Geng S., Penning de Vries F.W.T., Supit I., 1986: *A simple method for generating daily rainfall data*, Agric. For. Meteorol., 36: 263: 376.

Kondracki J., 2000: *Geografia regionalna Polski,* Wyd. Nauk. PWN, Warszawa.

Krzywicka-Blum E. Bac-Bronowicz J., 1997: *Regionalisation based on taxonomic methods in cartographic models of agricultural environment*. Proc. of 18th ICA Conf., Stockholm

Lee, T. J., R. A. Pielke, T. G. F. Kittle and J. F. Weaver. 1993*: Atmospheric Modeling and Its Spatial Representation of Land Surface Characteristics, in Environmental Modeling with GIS* (Goodchild, Parks and Steyaert, eds.), Oxford University Press, New York.

Linsenbarth A. 2000: *Krajowy System Informacji Przestrzennej.* Mat. X Konf. NT „Systemy Informacji Przestrzennej", Zegrze.

Maidment, D. R. 1993. *GIS and Hydrologic Modeling, in Environmental Modeling with GIS* (Goodchild, Parks and Steyaert, eds.), Oxford University Press, New York.

Obrębska - Starkel B., 1996: *Differentiation of topoclimatic conditions in a carpatian foreland velly based on multiannual observation:*, ZN UJ, Prace Geograficzne, z 101.

Podlacha K., Szeliga K. 1999: *Układy odniesień przestrzennych w aspekcie tworzenia i funkcjonowania SIP w Polsce.* Prace IGiK, T XLVI, z 99, Warszawa.

Quitt A., 1992: *Topoclimatic types in Central Europe, Atlas of Eastern and Souteastern Europe*, Gebrueder Bornlaeger Verlagsbuchhand Uing. Berlin-Stuttgart.

Yang X., Hodler T., 2000: *Visual and Statistical Comparision of Surface Modeling Techniques for Point-based Environmental Data*, Cartogr. and Geogr. Inform.Science Vol. 27, no. 2.

Wilson, J.P., W.P. Inskeep, J.M. Wraith, and R.D. Snyder. 1996: *GIS-based solute transport modeling applications: scale effects and estimation methods*. J. Environ. Qual. 25: