

Possibilities of the Application of Fuzzy Sets Theory in
Meteorology and Biometeorology

Vít Květoň, Institute of Balneological Research, Mariánské Lázně.

The aim of the paper is to demonstrate briefly some meteorological and biometeorological problems the solution of which requires application of fuzzy technics.

Weather forecasting evaluation

The simplest utilization of fuzzy sets is closely connected with automatic evaluation of weather forecast successfulness for specific localities.

In Czechoslovakia the weather forecasts are evaluated in the way that a weather forecasting expert transfers the verbally characterized forecast into five numerical values representing: average minimum and maximum day temperature of the air and average duration of sunshine in the region of Bohemia and Moravia, the percentage of the weather stations with the occurrence of precipitation and the percentage of the stations with thunderstorm (warm period) or fog (cold period) occurrence in the above mentioned region. The level of coincidence of this forecasted data with the real situation is being evaluated by means of five interval scale for every meteorological element separately; the thunderstorm occurrence is being evaluated by a four interval scale. For example, the

temperature forecast is considered as 100 % successful when the difference between the forecasted and real values is equal or less than 2 °C. The difference 2,1 - 3 °C is considered as 80 % successful, 3,1 - 4 °C performs 60 %, 4,1 - 5 °C is considered as unsuccessful. The total successfulness of the forecast is calculated as the weighted average of particular meteorological elements.

The method of evaluation mentioned above in some cases distorts significantly the weather forecasting results as, e.g., the very small increase of error from 2 - 2,1 °C performs, when using this method, the distortion decrease as for successfulness from 100 % to 80 %. Similar misinterpretation can occur very often when evaluating other elements as well.

The principal disadvantages of the procedures used so far are firmly rooted first in subjective judgement of the transfer of the forecast in verbal form to the numerical which is as a rule simplified by the synoptician and secondly in the fact that it does not enable to evaluate the whole scale of subtle nuances of the forecast as e.g. "the rain from the southwest gradually during the day", "snowing in higher areas", "in the valleys", "in the localities with the sky clear up" etc. This may distort the weather forecast evaluation from the point of weather local changes both in the positive and negative sence.

The evaluation of weather forecast by means of fuzzy

technics enables to surmount the above mentioned problems effectively and remove current disadvantages of the method used at the present time.

Weather typization

Theory of fuzzy sets can be applied very attractively in the field of weather typization. The application concerns both the current meteorological and climatological purposes and requirements of the research oriented on weather influence on different biological aspects.

Basic goal of weather typization or classification is to characterize main features of weather conditions in a certain period of time in a certain locality (or a region) by means of one qualitative indicator of the weather in the framework of selected types. It is to stress that in the case of weather types classification, a complex of very intricate relations and processes is being taken into consideration, when interferred and mutually conditioned factors and processes are irregularly changing their intensity and character. The adjustment of specific weather conditions to certain types of weather is thus very difficult. This is valid namely in the cases when specific weather conditions differ from the type models or are on the boardline of one or more types of weather. The weather types evaluation using classical synoptical methods

are necessarily influenced by subjective factors, which causes that every meteorological, namely biometeorological, institution creates its own or at least slightly adapted typization of weather of its own.

The above mentioned subjective factors cause that the results of biometeorological research gained by means of the same weather typization in different institutions or by different teams of typizators could not bring absolutely comparable results. To maintain the unity in interpretation of typization in acceptable tolerance is not an easy matter even within one institution.

Local weather typization represents a specific problem as it is not the matter of current practice. Weather typization is very challenging and the hour exactness is being required when stating limits of particular types. This fact has its consequences e.g. in exploring the influence of weather on biological functions given with hour accuracy, when studying climatographical problems of spa localities etc., generally in studying problems for which the long term catalogues of weather conditions should be at the disposal.

Fuzzy technics represent very prospective method, which could enable to realize objective weather typization with the help of some vague terms. The objectivization and operacion-alization of not precisely defined terms represent the only possibility how to express the high complexity of the problem.

It is to stress, however, that it is no method which could remove the uncertainty of weather types. The method can enable to define existing uncertainties and create the preconditions for making the weather types comparable, i.e., to base the typization on coincident methodics using entirely accurate way of interpretation of weather conditions and precisely defined unified level of uncertainty. This is the basic precondition for biometeorological research as well. The exact definition of the rules and the methodics of typization represents a necessary assumption for the automatic weather typization with the help of computer technics.

Longterm weather forecast

The problematics of weather typization is closely connected with some longterm forecasting methods based on exploring and searching for analogic weather situations. Here, as well, fuzzy technics application could bring interesting results and incentives not only from the point of view of classification and searching analogous synoptic situations, but from the point exploring analogical weather course in longer time horizont.

Short - and middleterm weather forecast

The present time weather forecasts for the time span from

one to five days are based on enormous amount of materials, being worked out on the basis of meteorological observations and on the principles of very advanced physical and mathematical models. These models make it possible with relatively high reliability to analyze and forecast barical respectively thermobarical fields for tens hours. The automatized objective analysis and forecast of surface synoptic chart is still in the early stages. Application of fuzzy technics could bring a lot of possibilities how to advance in this field.

The utilization of expert systems represent another direction as for fuzzy analysis for automatic or semiautomatic formulation of meteorological or biometeorological forecast. Automatized weather forecast could be thus based, e.g., on the results of classical objective forecasts of thermobaric fields, results of the fuzzy analysis of surface synoptic chart and on the expert knowledge of probable weather development in given area or locality. This expert knowledge could be put in the model either interactively by the expert for every particular case or could be considered partly or entirely as the component of computer databasis.

The expert system could be, for given purposes, utilized in classical form; but from experience gained so far in other fields of application, the utilization of fuzzy technics could simplify the whole procedure significantly. It is evident that the methods with the help of fuzzy technics are

most efficient namely in weather forecasting respectively by forecasting of weather for biological purposes as for small areas and particular localities; thus they enable with the help of small computer to realize local forecast for more localities respecting their orographic specificities.