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Evaluation of 1961-1990 Standard Climatological Normals

Ocjena standardnih klimatoloških normala za razdodlje 1961-1990.

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Abstract

The comparison of standard climatological normals for the periods 1931-1960 and 1961-90 indicates a certain increase in winter temperatures and a decrease in summer temperatures in Croatia. In the monthly precipitation totals there is an opposite trend. Weakening of the continental climate characteristics has recently been accompanied by a decrease of interannual variability of mean monthly temperatures. Temperature normals for the 1961-90 period approach more closely the mean values for the entire period of observation in Zagreb than any other standard normals. It is shown that the often advocated advantage of short period (5 or 10 years) normals as a more reliable basis for future value estimations, has no justification.

Key words: climatological normals, climatic fluctuation, Zagreb, Croatia

Sažetak

Usporedba standardnih klimatoloških normala za razdoblja 1931-60. i 1961-90. pokazuje stnoviti porast temperatura zimi i smanjenje ljeti. U mjesečnim količinama oborina postoji obrnuti trend. Slabljenje kontinentalnih obilježja klime u novije vrijeme praćen je i smanjenjem međugodišnje promjenljivosti srednjih mjesečnih temperatura. Normale temperatura za razdoblje 1961-90. su najbliže srednjim vrijednostima na osnovi svih mjerenja u Zagrebu u proteklih 130 godina. Pokazano je da često spominjana prednost normala iz kraćih vremenskih razdoblja (pet ili deset godina) kao pouzdanijih procijena budućih vrijednosti nema realnog opravdanja.

Ključne riječi: klimatološke normale, klimatske fluktuacije, Zagreb, Hrvatska

1. Introduction

In the past, when a relatively modest amount of meteorological data was available, and when the climate of a certain location was considered to be unchangeable, all the available data were usually used for the determination of climatic normals. Comparative climate analyses on a regional or global scale required reference to the same period, so in 1935 the IMO accepted 1901-1930, 1931-1960 etc. as standard periods for the computation of the mean values which are accepted as climatological normals (WMO, 1967). The choice of a 30-year interval can be considered as the only possible at the time. It was a compromise between the optimal period length and the amount of data available at the time.

Nowadays it is customary to renew

the climatological normals every full decade, and not only after every 30-year period, in order to follow the recent climatic conditions. Therefore the expression "standard climatological normals" is to some extent losing its original meaning. The standard normals for the period 1931-60 were used as a basis for numerous climatological atlases (WMO, 1971; SHMZ, 1967), and the characteristics of these normals were described by Šinik and Pleško (1967).

Climatological normals serve various purposes. They are used in the description of the spatial distribution of climatological elements in a region. A comparison of normals derived from different periods can help in the evaluation of possible climatic changes. On the other hand, a comparison of mean values for a shorter period (a month or a season) with normals, gives an objective assessement of the anomaly values, which helps in the assessement of possible negative consequences that usually accompany more significant anomalies. Probably the most frequent application of climatological normals is in the field of socio-economic planning where the normals serve as estimates of future values.

Climatological normals should not be under the influence of the specific characteristics of the climatic conditions during a certain period but they should rather represent more general characteristics. Therefore we have considered it necessary to compare the normals for two consecutive standard periods and to find how much they differ from the long-term averages. Such an analysis was possible by using data set for the Zagreb-Grič Observatory (where meteorological mesurements have been performed since 1862) and several other climatological time series in Croatia. In this paper we shall restrict ourselves only to the comparison of mean monthly air temperatures and precipitation totals.

2. Comparison of normals for two standard periods

The comparison of the mean values for the 1961-90 and 1931-60 periods provides an insight into the possible climate changes. Differences between the mean monthly air temperatures over these two periods for a number of places in Croatia are given in Tab.1. The signs of differences for certain months indicate an obvious tendency towards grouping. Nearly all the stations show a temperature increase in the first three months of the year, while in the other months, especially in summer, there is a certain cooling. Therefore the main characteristic of the climatological normals for the 1961-90 period is a decrease in the annual range of air temperature. Though the signs and even the difference amounts are similar for most places, it can still be noted that for some places they differ (Pazin for example). The explanation of this phenomenon should be searched for in data inhomogeneity. There are few places where measurements have been taken continuously at the same location long enough to include both standard periods. Data for Rijeka and Slavonski Brod have not been included into the table because the meteorological stations at those places were relocated several times. The data inhomogeneity as a result of a station relocation is a very common occurrence in meteorological practice. This fact may be the reason why a 30-year period still remains optimal. It is long enough to give real estimates of the average conditions, and at the same time not too long to be a limiting factor for the number of stations having had uninterrupted observation during the entire period at the same location and under nearly the same environmental conditions.

Of all the data listed in Tab.1. only those for the Zagreb-Grič Observatory seem suitable for a detailed comparative analysis. The results of a two-tailed t-test of these data indicate that only the difference for August is significant at the 0.05 level.

Precipitation amounts show a tendecy towards increasing in the warm, and decreasing in the cold half of the year.

Already Makjanić (1979) indicated a recent strengthening of the maritime climate characteristics in Croatia which are manifest in the decrease in the annual range of air temperature. Goldberg (1954) found in the climate of Zagreb a certain tendency towards an alternation of periods with more pronounced and less pronounced continental charac-

Tab.1. Diferences between mean monthly and yearly air temperatures for the 1961-90 and 1931-60 periods for various places in Croatia.
Tab.1. Razlike između srednjih mjesečnih temperatura zraka u razdoblju 1961-90. i 1931-60.

Station \ Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
OSIJEK	-0.1	+0.5	+0.2	-0.2	-0.1	-0.5	-0.9	-0.8	-0.5	-0.1	-0.6	-0.7	-0.3
DARUVAR	+0.6	+1.0	+0.3	-0.4	-0.1	-0.1	-0.4	-0.7	-0.4	0.0	-0.4	-0.7	-0.2
VARAŽDIN	+0.5	+1.0	+0.5	-0.1	-0.1	-0.2	-0.7	-0.2	-0.5	-0.2	-0.5	-0.5	-0.1
ZAGREB-MAKSIMIR	+0.4	+1.4	+0.4	-0.4	-0.2	-0.4	-0.6	-0.7	-0.4	0.0	-0.2	-0.4	-0.1
ZAGREB-GRIČ	+0.3	+0.9	+0.5	-0.2	-0.1	-0.5	-0.7	-0.7	-0.7	+0.1	-0.2	-1.8	-0.2
KARLOVAC	+0.1	+2.1	+0.6	-0.2	-0.2	-0.6	-0.4	-0.6	-0.5	+0.1	-0.6	-1.8	-0.2
OGULIN	+0.3	+1.8	+0.2	-0.5	-0.7	-1.0	-1.0	-1.4	-0.9	-0.2	-0.4	-1.2	-0.4
GOSPIĆ	+0.5	+1.5	-0.1	-0.3	-0.2	-0.8	-0.4	-0.8	-0.7	0.0	-0.6	-1.9	-0.3
CRIKVENICA	+0.2	+0.3	-0.1	-0.8	-0.8	-1.0	-0.7	-0.7	-0.6	+0.1	+0.1	-0.3	-0.4
PAZIN	0.0	+0.2	-0.1	-0.5	-0.3	+0.1	-0.7	+0.2	-0.8	-0.2	-0.3	-0.6	-0.3
PULA	0.0	+0.2	-0.2	-0.2	-0.4	-0.5	-0.5	-0.6	-0.8	-0.1	-0.3	-0.7	-0.4
MALI LOŠINJ	+0.6	+0.2	+0.1	-0.4	-0.8	-0.6	-0.7	-0.6	-0.6	+0.3	+0.2	-0.2	-0.2
ZADAR	+0.9	+0.6	+0.2	-0.1	-0.6	-0.2	-0.5	-0.3	-0.2	+0.2	+0.5	-0.1	0.0
KNIN	+0.1	+0.6	+0.3	-0.4	0.0	-0.9	-0.2	-0.8	-0.7	0.0	-0.4	-0.9	-0.3
ŠIBENIK	+0.4	+0.3	+0.3	0.0	0.0	-0.4	-0.1	-0.3	-0.2	+0.2	+0.4	-0.1	0.0
SPLIT-MARJAN	+0.4	+0.3	+0.3	-0.2	+0.1	-0.3	-0.2	-0.5	-0.3	+0.1	-0.1	-0.1	-0.1
HVAR	+0.2	+0.2	+0.1	-0.1	-0.1	-0.5	-0.4	-0.4	-0.2	0.0	-0.1	-0.2	-0.1
LASTOVO	+0.2	+0.1	+0.2	0.0	0.0	-0.3	-0.1	-0.1	+0.1	+0.2	-0.1	0.0	0.0
DUBROVNIK	+0.2	0.0	+0.5	+0.2	0.0	-0.2	-0.1	-0.1	0.0	+0.6	+0.2	0.0	+0.1

teristics. Therefore normal values for the 1961-90 period should be considered not only with regard to the previous standard normals but also within the framework of all the data observed.

3. Comparison with long-term normals

The considerations in the previous section have pointed out certain differences between the last two standard climatological normals. It is obvious that 30-year periods are not long enough to ensure the differences between normals to be negligible. In this section an attempt is made to answer the following two questions: which of the two considered periods provides a better representation of the climate in Croatia, and which of them could serve as a more reliable estimate for future climate conditions. The majority of the previous investigations (Enger, 1959) indicate that recent normals are more reliable for the estimation of future values. This is quite obvious, because a large number of climatological data shows a more or less clearly pronounced trend which, however, is not a consequence of global climate changes but most usually of changes in the station environment. On the other hand, the differences between particular periods could be regarded as the consequence of climatic fluctuations. In this case the comparison of short-range and long-range averages would lead to a relatively simple answer to the question of how accurate the description of essential climatic characteristics by means of short-range averages really is.

In this section, the mean monthly temperatures and monthly precipitation totals in Zagreb for the 1862-1991 period serve as a basis for comparison of certain short range means. Though our principal intention has been to find out how much the mean values of particular 30-year periods differ from the long-range means, we have also taken into consideration values for other periods from 5 to 50-years. 1912 was the erliest year in the

1862-1991 period for which averages were avaiable for all considered periods

Different measures can be used in order to assess how close a particular period normals are to the average values derived from the entire data set. Among the possible measures we suggest the following:

$$S = \sum_{i=1}^{12} \frac{(x_i - x_{Li})^2}{s_{Li}^2/n} \qquad (1)$$

where x_i is the mean monthly value of the considered climatic element in the month i which was calculated on the basis of data from a n-year period, and x_{Li} and s_{Li} are the mean monthly value and the standard deviation for the entire period of observation (130 years for Zagreb). The suitability of this measure lies in the fact that the distributions of S do not depend on the period length (n) and the variability in a particular location (s_{Li}). They all have an approximate χ^2 distribution with 12 degrees of freedom, providing an objective determination of how close normals based on the short-range periods are to the long-range mean values. Fig.1. represents the frequency distribution of S values

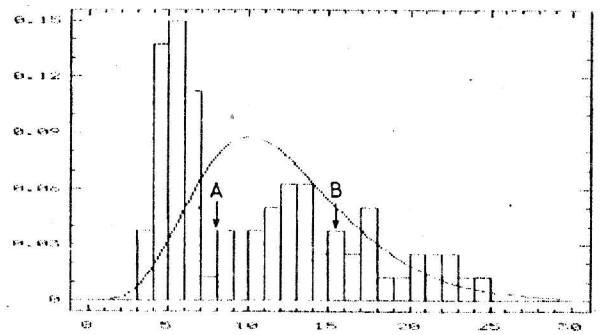

Fig.1. The observed histogram of values S for the mean monthly temperature defined with Eq. (1) for overlapping 30-year period in Zagreb (from 1882-1911 till 1961-90). The letters A and B indicate the S value for the 1961-90 and 1931-60 normals respectively. The curve represents the χ^2 distribution for 12 degrees of freedom.

Sl.1. Histogram relativnih čestina veličina S definiranih relacijom (1) za srednje mjesečne temperature zraka za osamdeset 30-godišnjih kliznih razdoblja u Zagrebu. Slova A i B pokazuju iznos veličine S u razdoblju 1961-90, odnosno 1931-60. Krivulja predstavlja χ^2 razdiobu sa 12 stupnjeva slobode.

for the mean monthly temperatures. The emppirical distribution is quite different from the expected theoretical one. Normals for the period 1961-1990 belong to the group for which the S values are relatively small and are found on the left side of the distribution. A small value of S indicates close agreement of the mean monthly air temperatures in that period with the corresponding values for the entire period of observations 1862-1991. Standard normals for the period 1931-1960 belong to the group with a large value S scale, i.e on the right tail of the empirical distribution, indicating that these normals significantly differ from long-period averages.

It is expected that climatological normals represent not only the annual variation of an element's mean value, but also the most accurate description of its interannual variability. This can be derived from Gibbs' (1987) suggestion of the definition of climate: "Climate is the statistical probability of occurrence of various states of the atmosphere over a given region during a given calendar period". The standard deviations in the last 30-year (1961-90) mean monthly temperatures in Zagreb are smaller in all months, except March, than the corresponding values for the 130-year period (Tab.2). This seems to be an additional argument in favour of the recent increase of the maritime characteristics in the climate of Croatia. However, from the ratios of the largest and smallest variances for four 30-year periods (1871-1900, ..., 1961-1990) according to the modified Bartlett test (WMO, 1966, page 68) we could not conclude that any significant change existed in the variability of the mean monthly temperature of any particular month. The acceptance of relatively small standard deviation values for the 1961-90 period as "standards", can lead us into situation to judge the future value from a somewhat distorted perspective. An apparent increase in the frequencies of the extremely cold or extremely warm months could be the consequence of small values of standard deviation which are accepted as the measure for the natural interannual variability of the monthly means. Short-time series may give us quite unrepresentative values for variability. That is another argument to support our suggestion of defining the normals

Tab. 2. The mean values of temperature and precipitation amounts and their variability for Zagreb-Grič based on data for periods A (1961-1990) and B (1862-1991).

Tab. 2. Srednje mjesečne temperature i količine oborina u Zagrebu, te njihova promjenljivost u razdobljima A(1961-1990) i B (1862-1990).

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature (°C)													
A	0.5	3.1	7.2	11.8	16.3	19.4	21.3	20.6	17.0	11.9	6.4	2.0	11.5
B	0.1	2.3	6.9	11.7	16.2	19.5	21.7	20.8	17.2	11.8	6.2	1.9	11.4
Standard deviations													
A	2.46	2.79	2.42	1.42	1.41	1.07	1.18	1.19	1.42	1.38	2.06	2.10	0.56
B	2.85	3.01	2.25	1.57	1.72	1.34	1.30	1.32	1.54	1.57	2.07	2.53	0.72
Precipitation (mm)													
A	53	47	58	65	83	101	87	91	81	70	85	62	883
B	51	47	55	67	84	97	83	83	82	91	83	64	886
Coefficient of variation													
A	0.66	0.56	0.38	0.50	0.50	0.33	0.55	0.60	0.41	0.75	0.66	0.54	0.154
B	0.61	0.68	0.52	0.47	0.46	0.41	0.54	0.58	0.56	0.61	0.60	0.57	0.168

for the periods longer than 30 years.

The variability of monthly precipitation amounts in 1961-90, expressed by the coefficient of variation, is, somewhat smaller in comparison to previous periods. This is particularly true for the month of March, June and September (Tab.2).

4. Climatological normals as projections of future values

The significance of the future values of climatological elements is best seen from the great efforts invested into reaching these values by means of dynamic climatological models or long-range weather forecasts. Since these methods are not reliable enough, climatological normals retain their competitive ability as a means by which estimation of future values is reached in the simplest and least costly way. There are two kind of difficulties connected with the assessment of the advantages or drawbacks of a particular method by which the estimation of future values of climatic elements can be reached: A long time is needed for the evaluation of the reliability of various methods. Their evaluation on already observed data need not be a guarantee that identical relationship will be maintained following a real evaluation on the future values. A second, but not less important problem is that there are no generally accepted criteria for discrimination between successful and errorneous climatological projections. The terms projections and estimates are used here rather than forecasts or previsions just to indicate that they are based on simple extrapolation.

Investigations by Lamb and Changnon (1981) were aimed at finding out which period of time was optimal to derive mean values closest to the immediately following observed values (the rate of deviation not being important). Their results, based on the data for three stations in the State of Illinois, showed that the mean values for the period of last 10-years (for precipitation), and even for 5-year periods (for temperature), were usually closest to the mean seasonal values in the year immediately following those periods. This result, no matter how paradoxical at first sight, is frequently mentioned in literature, sometimes without mentioning the criteria which served as a basis for reaching the optimal period (Changnon, 1985). Sometimes it can create a misleading impression that short-term climatological normals ought to be considered as optimal predictor of future values in the most general sense, there-

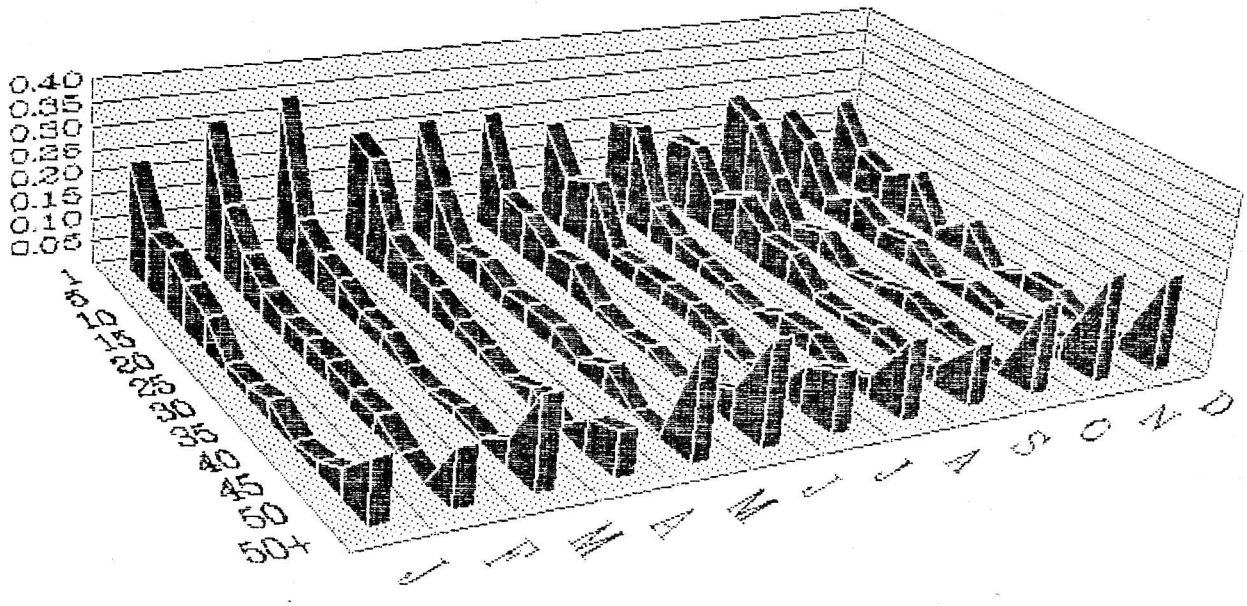

Fig.2. The frequencies with which different climatic normals were closest to the observed value of the mean monthly temperature in the immediately following year. The projection of monthly temperature for Zagreb were made for the period 1912-1991.

Sl.2. Relativne čestine kada su različite normale bile najbliže opaženoj vrijednosti srednje mjesečne temperature u sljedećoj godini. Projekcije se odnose na vrijednosti u Zagrebu u razdoblju od 1912 do 1991.

fore even for a description of the future and the recent climate of a certain site. Since the standpoints found in the mentioned papers have had a significant influence on present meteorological literature (Kunkel and Court, 1990), it may be useful here to bring up some of our results which raise the question of a greater reliability of short-term over long-term normals for future projection.

In our investigation, based on the mean monthly temperatures for Zagreb-Grič in the period 1862-1991, we have tested the ability of different normals to serve as basis for an estimation of the following value in the time series. We have taken into account 5,10, ..., 50-year period "normals". We have also, investigated normals calculated on the basis of all available data till the year for which the values are being estimated. These normals were calculated for periods not shorter than 50 years (in the Figures they are marked 50+). Previous year values, as the simplest projection of the future value, have also been included. This projection is marked 1 in the Figures. Fig.2. represents the relative frequencies in cases when a particular investigated "normal" was closest to the immediately following value. In almost all months the frequency distributions have a characteristic U-shape. They will not change significantly for another climatic element or if a fewer number of different normals is considered. It appears that the mean monthly temperature in a particular year can serve as the best projection for the following year. At first sight this is a very surprising result. It is true that cases of similar temperatures in consecutive years are not rare. This can be seen in the Fig.3a, which represents 232 (out of a total of 960) pairs of standardized values of monthly temperature anomalies in the years for which the previous year value (A_0) was the most accurate estimate of the value of the following year (A_1). These pairs, represented by points are distributed around the straight line $A_0=A_1$. There are relatively few points around the origin, though such cases are most frequently encountered. In such cases projections of a large group of different normals turn out to be the most accurate projections. These are the most frequent cases (Fig.3b). However, if we take into acco-

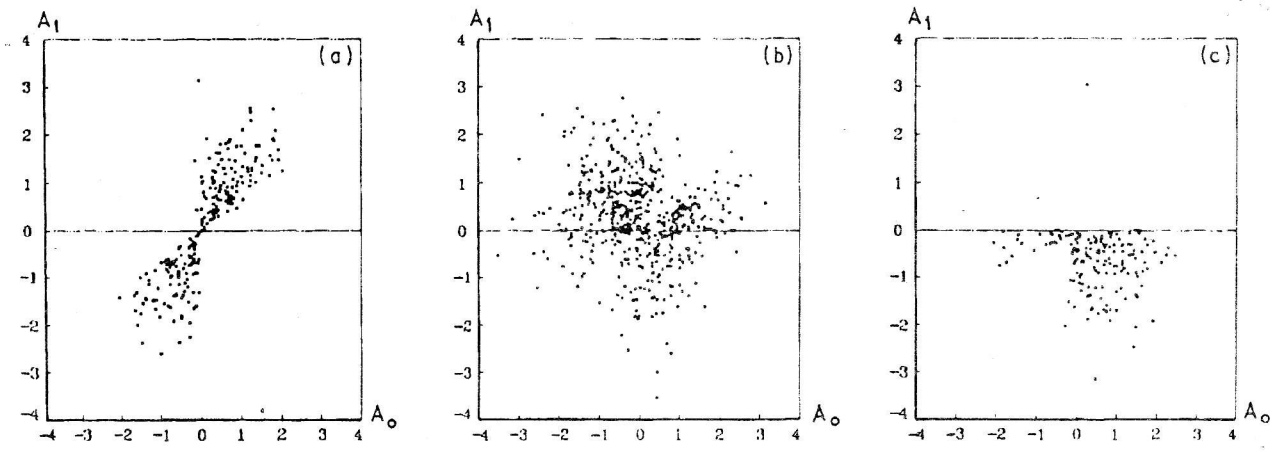

Fig.3. The points represent the pairs of corresponding standardized mean monthly temperature anomalies in successive years when: (a) the value (A_0) in the preceding year was closest to the following value (A_1); (b) one of ten various normals was the best projection; (c) the mean of all available data (for at least 50 years) was closest to the observed value in the following year.

Sl.3. Pojedina točka na dijagramu predstavlja par vrijednosti standardiziranih srednjih mjesečnih temperatura u uzastopnim godinama kada je: (a) vrijednost u prethodnoj godini (A_0) bila najbliža vrijednosti u sljedećoj godini (A_1); (b) najtočnija procjena sljedeće vrijednosti je neka od deset razmatranih "normala"? (c) srednja vrijednost svih do tada raspoloživih podataka bila je najbliža opaženoj vrijednosti u sljedećoj godini.

unt that there are ten different normals being considered, the percentage per normal is very low, creating a misleading impression that "normals" are unreliable predictors for future values. Fig.3c shows an interesting feature: the projections based on the mean value of all avilable data (not shorter than 50 years), prove to be the most accurate only in the case when the mean monthly temperatures in the following year are below the long-term mean. This is explained by the fact that the values of those normals are relatively low due to the permanent influence of a relatively cold period towards the end of the 19th century. However, the comparison of different normals in the way represented in Fig.2, which is similar to the one applied by Lamb and Changnon (1981), is not correct. The projection based on the value observed in the previous year is confronted by a large number of projections based on different normals which are very similar to each other. An entirely different picture is obtained when a correct comparison of particular normals in pairs is applied. In Fig.4. the curve (a) represents the distribution of all the cases which are in Fig.2. represented for each month separately. However, if we compare the reliability of each of the considered normals with the reliability of a projection based on the previous year value, an entirely different picture is obtained (line b). All the considered normals show an advantage in relation to the simple extrapolation of the previous value. Line (c) represents the relative frequencies of cases when the projection based on a particular "normal" was closer to the following observed value than the projection based on all available data. Therefore, from this figure it is clearly seen that short-term normals (5-year) are inefficient.

Besides the very seldom used criterion of the "closest value" a much more used criterion in the comparative investigation of normals' predictability is the mean-square-error (MSE). Fig.5. represents MSE for projections of immediately following standardized values (A_1) based on various normals. It is a well known property of random time series that the intersequential variability (or MSE for projection on the basis of previous values) is twice higher than the variance (or MSE for projections based on the mean of the whole series). The time series of mean

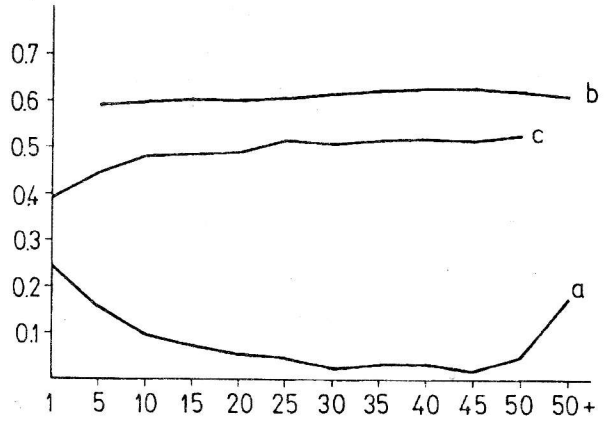

Fig.4. The frequencies with which various normals were closest to the corresponding value in the following year: (a) when all twelve normals were compared simultaneously; (b) only in comparison with the capability of projections based on the value in the preceding year; (c) only in comparison with the normals computed from all the available data (50+)

Sl.4. Relativne čestine kada su pojedine "normale" bile najbliže odgovarajućoj vrijednosti u sljedećoj godini u slučaju: (a) da se svih dvanaest razmatranih normala istovremeno međusobno uspoređuju; (b) samo u usporedbi sa projekcijom na osnovi vrijednosti iz prethodne godine; (c) samo u usporedbi sa srednjom vrijednošću izračunatom na osnovi svih do tada raspoloživih podataka.

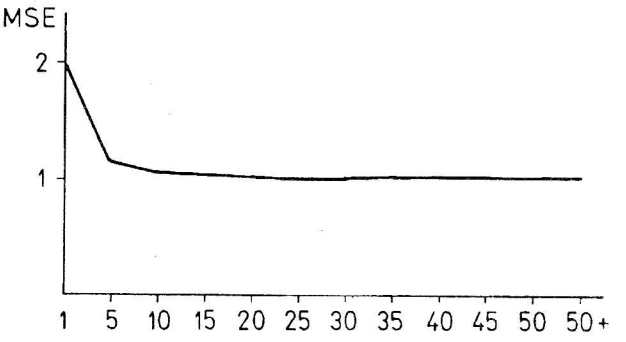

Fig.5. Mean-square-errors of the projections of the standardized mean monthly air temperature for the following year in Zagreb based on climatic normals of various length.

Sl.5. Srednje kvadratne pogreške projekcija standardiziranih srednjih mjesečnih temperatura u sljedećoj godini koje predstavljaju ekstrapolaciju različitih "normala".

monthly temperatures in Zagreb demonstrate the same ability. Data presented in Fig.5 do not show the advantage of any normals with respect to the normals based on all available data. However, there is no great difference, with regard to the MSE of standardized anomalies, between the short-term (10-years) and long-term normals. They are all close to unity. In other words, none of the normals can be expected to have a smaller MSE than the variances of the whole series. The former is in agreement with the point brought up by Court (1968) that climatic normals are inefficient as the point predictors of future conditions. We suppose that today there are various statistical or dynamic models which permit a better projection of climatic conditions in the near future than the climatic normals. These models cannot demonstrate their ability because the minimum period required for their operational evaluation is very long. The non-existence of defined criteria for their evaluation also contribute to the fact that their relatively small advantage over projections based on normals remain neglected.

5. Conclusion

Comparisons of the 1961-1990 standard normals with the corresponding 1931-1960 values as well as with the long-range mean values have indicated certain specific properties of the recent climatic condition in Croatia. The climatic fluctuation is manifest in the decrease of the annual air temperature range and a relatively small interannual variability. One can assume that the identified strengthening (weakening) of maritime (continental) characteristics is not limited only to the considered area but that it spreads much further.

It is pointed out that climatological data for a very limited number of places in Croatia may be considered as homogenous. The main reason for inhomogenuity is the relocation of stations. Due to this fact it is neccessary to be very careful in the interpretation of the various climatological stati-

stics.

For the evaluation of climatological normals it appears necessary to compare those values with some of the longer period standard values. For this reason it would also be useful to define the standard normals for a much longer period. This would probably prove an advantage in the comparative analysis of climatic fluctuation on a global scale.

The comparison of 1961-1990 standard normals indicate that the annual variation of air temperature is very close to the corresponding values based on all available data (130 years). Interannual variations of monthly mean temperatures in the recent period are relatively small. There is a strong evidence that the annual range temperature decrease is accompanied by a decrease of interannual variability. This phenomenon, which is well known on a space scale, seems to appear in the same manner on the time scale.

Our investigations in the use of climatological normals as a predictor for climatological conditions in the near future show that the long term normals have advantages over the short-term ones. Indication by some authors that short-term normals, or even the previsious year values of a climatological element, may be the best projection for the following year, are not appropriate. A simultaneous comparison of various normals gives a misleading picture of certain advantages for candidates on the margins of the set of normals. The deficiency of short-term normals appears clearly when they are compared in pairs with long-term normals.

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Kratak sadržaj

Usporedba klimatoloških normala za standardna razdoblja 1931-1960. i 1961-1990. pokazala je da je u posljednjem razdoblju na području Hrvatske došlo do smanjenja godišnje amplitude temperature. Porast temperatura u zimskim i smanjenje u ljetnim mjesecima nije podjednako izraženo u svim mjestima (Tab.1). To se objašnjava posljedicom promjena lokacija pojedinih stanica. Vrlo mali broj mjesta raspolaže s homogenim nizom podataka koji bi mogli poslužiti za identifikaciju klimatskih fluktuacija.

Pokazalo se da su standardne normale iz razdoblja 1961-90. vrlo blizu dugogodišnjim srednjim vrijednostima. Međutim, prirodna međugodišnja promjenljivost, izražena u obliku standardnih devijacija srednjih mjesečnih temperatura, u svim je mjesecima (osim u ožujku) manja od odgovarajućih vrijednosti za cijelokupno razdoblje od 130 godina mjerenja u Zagrebu (Tab.2).

Klimatološke normale prvenstveno služe kao orijentacijska procjena budućih vrijednosti. U meteorološkoj literaturi mogu se naći vrlo različita mišljenja o optimalnoj

dužini razdoblja za izračunavanje srednjaka koji su osnova za procjene budućih vrijednosti. Uspoređujući različite procjene na neprimjeren način, može se steći pogrešan dojam da je vrijednost klimatološkog elementa iz prethodne godine obično najbliža opaženoj vrijednosti u sljedećoj godini (S1.2). Međutim, ako se uspoređuje pouzdanost različitih projekcija u parovima, tada postaje očito da su projekcije na osnovi višegodišnjih vrijednosti uvijek pouzdanije procjene buduće vrijednosti od procjene na osnovi vrijednosti iz prethodne godine (S1.4). Prednost višegodišnjih srednjaka posebno dolazi do izražaja ako se kao kriterij pouzdanosti uzme srednje kvadratno odstupanje (S1.5).